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ECONOMIC GEOGRAPHY

OCTOBER

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Dr. Jones, associate professor of economic geography at Clark University, contributes "The United States and Its Chief Competitors in South American Trade," the seventh and last article in a trade series on The Commerce of South American Republics. Dr. Rosenfeld of the Tropical Plant Research Foundation of Washington and Dr. Jones contribute in this number of the magazine, "The Cotton Industry of Peru," a study based on field work in the irrigated cotton valleys.

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THE AGRICULTURAL GEOGRAPHER

EVERY intelligent farmer, whether he be aware of the fact or not, is actually a regional geographer. He is a close student of his terrane, its relief, drainage, and soil; of the climate and weather of his region; of the natural vegetation, the introduced weeds, and the crops adapted to his territory. He knows something of the political system under which he works, of the economic conditions that affect his activities, and of the social obligations and privileges that accrue to his industry. He sees all these in their relationship to one another, to himself and his family, and to the community at large. In addition, he is somewhat acquainted with the essential facts of geography as they relate to his country, and he generally is as well informed as the average citizen regarding these same facts as they pertain to world relationships.

But in agriculture, as in commerce and industry, the need grows continually greater for trained students in the specialized field of agricultural geography, workers and investigators who can assemble intelligently the great mass of facts and figures that concern agriculture in its relation to physical and economic influences, who can organize and present them clearly and forcefully, and who can apply them to the solution of social and economic problems that confront the community and the state as a whole, as well as the farm groups themselves. American geographers trained in this special field are all too few, excellent and competent as these few are. To promote the best interests of the farmers, the manufacturers, the traders, and in fact the whole people, the number of agricultural geographers must be materially increased.

No country of all the world is so richly supplied with coal and other power, with iron and copper and lead and other minerals, with adequate capital and competent labor, all requisites for the development of great productive industries, as is the United States, and at the same time endowed with such great expanses of fertile soil, favorable climate, and level lands for the growth of food to feed its people, of fiber to clothe them, of wood and brick and stone to shelter them, of coal and oil and gas for their fuel as well as their power. To develop and utilize these resources, wisely, to husband them conservatively, and to guard them from ruthless waste or wanton destruction, the trained agricultural geographer should be the guide for the whole people.

ECONOMIC GEOGRAPHY

VOL. 3 OCTOBER, 1927 No. 4

THE UNITED STATES AND ITS CHIEF COMPETITORS IN SOUTH AMERICAN TRADE

Clarence F. Jones

Economic Geographer, Clark University

SINCE 1910 the United States has gained the dominant position in the commerce of most sections of South America. Toward this position it was moving before the World War with its far-reaching influences on the movement of commodities. The World War merely accelerated the commercial advance of the United States in this southern continent at the expense of strong competitors. The United States leads other countries in supplying goods according to values to all the republics except Argentina and Paraguay, and in purchasing the exports from the west coast, the north coast, and Brazil. In 1925 it had about 27 per cent of the trade of the continent, in contrast to 17 per cent in 1910 and less than 10 per cent in 1890.

Prior to the outbreak of the World War, two great nations competed actively with the United States for the trade of South America. They are still in the field, but can they come back to their pre-war positions? Other countries—France, Belgium, Holland, Italy, and Spain—held a fair share of the commerce; the trade of France was peculiarly individual; that of Belgium was large in proportion to the size and resources of the country. But each of the three great nations exhibited marked and different characteristics in the competition for the trade. The British for a long time purchasers of oversea foodstuffs and raw materials and venders of manufactured wares in foreign fields entered South America early and dominated the commerce until recently. The Germans entered the field late, but with cheap goods and trade methods backed by marked industrial expansion that advanced their interests at an amazing rate, before they were nipped by the war. The United States in the field for a long time advanced slowly but steadily, with the evolution of industries and trade at home, and gained a stronger and stronger foothold on the commerce of the southern republics without many of the efforts or trade methods of its competitors.

When the imperial colonial powers of Spain and Portugal waned and were shaken off, the British were the first to enter the South American commercial field; consuls and trade representatives hastened to several parts of the continent. Since, the numbers of British in South America increased to hundreds of thousands (Buenos Aires alone has 100,000). Along with these trade pioneers moved huge quantities of money for investment in railways, mines, and commercial enterprises; at home it was backed by the largest masses of free capital the world had known. British men and money have built the chief railways of Argentina, Uruguay, Brazil, Peru, Bolivia, and Chile; they have opened up many of the productive mines and they have directed the course of trade through loans, commercial organizations, and the

chief merchant marine of the world (Fig. 1). These essential pillars of commerce rested on strong natural bases of trade. The United Kingdom, a country with small agricultural resources, hungry millions of factory workers in a score of majestic manufacturing industries based on domestic iron ore, an abundance of high quality coal, and an early start, huge reserves of capital, and some water power, has for more than a century looked to the vast spaces and isolated mountain recesses of South America for foodstuffs and raw materials and for an expanding market for its manufactured wares. This trade net embraced within its many folds for a long time the chief currents of South American trade. It was the very essence of British prosperity and still is, but other trade nets were being woven by competing nations. Twenty years ago the United Kingdom had almost one-third of the total trade of the continent.

While Germany had already emerged as an industrial nation by 1870, its great participation in South American trade did not come until during the unification and industrial development of the German Empire following the Franco-Prussian War (1870–71) by which it acquired the Lorraine iron ores, and more than two million cotton spindles of Alsace, one of the oldest cotton manufacturing centers of Europe, increasing the nation's cotton spindles by 65 per cent. German trade expansion was accompanied by complete government dominance at home of industry, transportation, business, and trade, by the application of science to business to an unparalleled degree, by training men for the contests of commerce as well as they were for those of war, by the construction of a great merchant marine, by its financial fingers penetrating many parts of the continent, by a careful study of the desires of the people in different areas and making products to meet these needs, and by a price and long term credit competition that has baffled many commercial men. German trade with South American countries increased from small beginnings in 1870 to almost 300 million dollars in 1913, almost taking second place from the United States. As with the United Kingdom, Germany regarded its trade developments as the goal to which its best efforts should be directed. As an industrial nation with coal, iron, water power, money, textile mills, and cheap labor, it too looked to

FIGURE 1.—Among the numerous British trade activities in South America has been the shipment of purebred stock from the United Kingdom to the fertile Pampa of Argentina; this movement has been a prime factor in the improvement of the herds of that country, in changing the type of meat from frozen beef to first-class chilled beef for the English trade, and in placing Argentina in the front rank as a beef exporter.

South America for raw materials and foodstuffs and for a market. It considered active participation in this field a supremely important matter.

Capital went principally into nitrate fields, public utilities, banks, and commercial partnerships. Hamburg, with a thousand houses doing business all over the world, gave special attention to South America. Hamburg houses formed partnerships with large importing firms in all centers. Although German investments relatively were not large as compared with those of the United Kingdom, the commerce built up by all activities in a third of a century was not greatly inferior to that which England had taken three times as long to develop.

On the other hand, the United States until the past two decades looked at South American trade in a different light (Fig. 2). The nation did not consider the trade vital to development. Except for a few engineers and miners, a limited number of Americans entered South America; no stream of money like that from the United Kingdom financed enterprises, which foster commerce. No banks were established; and few steamship lines afforded transport facilities; it has not been so many years since an American merchant, arriving in Valparaiso or any other leading port in South America, stepped from a British liner, sought credit information at an English, German, or Italian Bank, shipped his goods on a foreign vessel, and trusted to foreign institutions to collect his money. Yet in spite of these commercial handicaps the United States trade has incerased greatly.

THE GROWTH OF TRADE

Attention focussed upon the trade of the United States with South America since 1914 has given the impression that trade before that time was negligible; but such was not the case. United States trade with South America had its real beginnings more than a century ago, when American merchants and fishermen were well known in most parts of the world. It amounted to 10 million dollars in 1830 and increased slowly to 140 million in 1900, without special aids or inducements other than the natural bases of exchange (Fig. 3). During this period when the British and the Germans were making great efforts to dig deep in

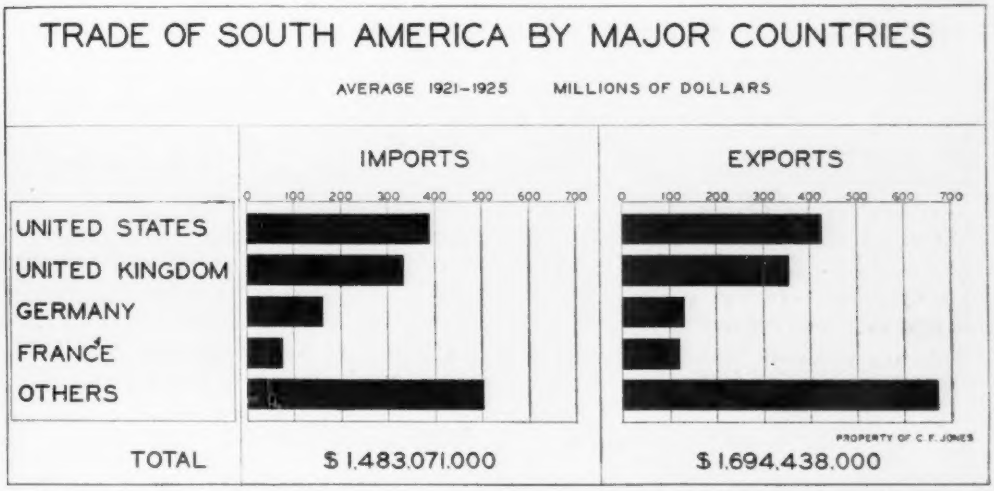

FIGURE 2.—Notwithstanding its slow commercial progress in South America before the war, the United States now leads all countries in the trade of this continent, having surpassed the United Kingdom, the first in the field and the leader for a century, and having far outdistanced Germany, which was a close rival in 1913. Four countries handle 65 per cent of the imports and 61 per cent of the exports of South America.

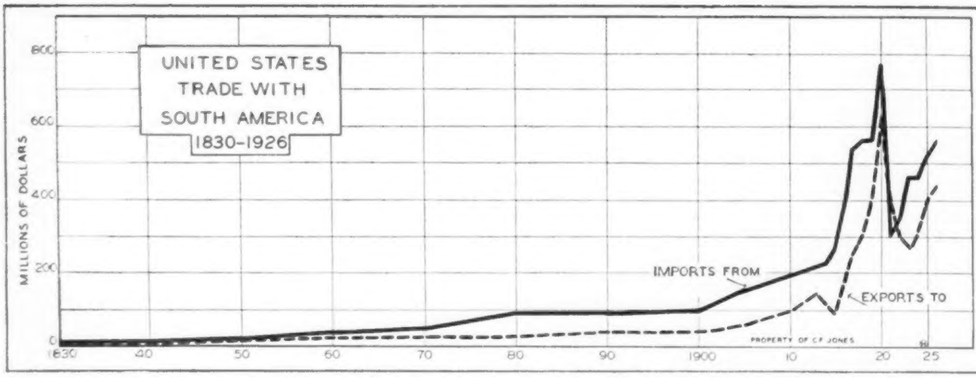

FIGURE 3.—United States trade with South America increased slowly from a scant 10 million dollars in 1830, to 140 million in 1900. The chief expansion of the United States in this field has come since 1914, although many developments previous to the outbreak of the World War had paved the way for a considerable advance. The war only accentuated a movement already under way.

South American commercial trenches, the United States had no trade policy for this part of the world. The people knew little of its opportunities; they did not need the markets, and profitable employment for capital at home kept them from looking southward.

From 1900 to 1914 the receipts and shipments with South America more than doubled. Something in the nature of a systematic policy to enlarge interchange of goods in South America developed. The Panama Canal, one of the greatest engineering feats of all time, was being completed. American medicine and sanitation entered South America by way of the Panama Canal Commission and through the Rockefeller Foundation, which to date has practically eliminated the smoldering fires of yellow fever. Mining men, engineers, and money began to enter various parts of the continent, as well as some American manufacturing concerns. All these developments increased the demands for United States goods in South America and made way for larger purchases of raw products from that part of the world.

Shipments from the United States consisted of petroleum products, lumber, mining machinery, agricultural machinery, steel rails, railway equipment, miscellaneous iron and steel products, electrical supplies, flour, lard, bacon, and that wide-embracing category known as general merchandise. Few textiles moved from the United States in spite of the fact that they were the chief imports of the whole continent. The shipments included no primary raw materials. They consisted for the most part of manufactured and semi-manufactured wares. On the other hand, purchases from South America comprised primary raw materials—rubber, the commodity which accounted for a considerable proportion of the increase until the rubber bubble of high prices burst in 1912, hides, wool, copper, nitrates, some precious metals, and quebracho extract—and tropical foodstuffs—coffee, the chief interest of the United States in Brazil and Colombia, cacao, the chief product of Ecuador, and bananas from the Caribbean coast.

This movement of commodities was indicative of the trends of development in United States trade and industry. The nation was becoming an industrial country, looking to overseas regions for a market for manufactures and for supplies of raw materials and tropical foodstuffs. This was the basic cause for the greater commercial expansion of the United States into South America, in fact, into all parts of the world, with the exceptions of industrial Europe, during this period.

The proportion of our total exports represented by manufactures has steadily

increased from 5.66 per cent in 1820 to 30 per cent in 1914 and to 41.5 per cent in 1926; if semi-manufactured articles be included, the percentage for 1914 was 45 and that for 1926 was 55.4; manufactured foodstuffs included another 10.7 per cent in 1926. Our purchases of manufactured wares have dropped from almost 60 per cent (1820) to less than 20 per cent in 1926.

At the same time the exports of foodstuffs and raw materials (until interrupted by the World War) decreased materially (foodstuffs from almost 50 per cent in 1876–80 to only 17.8 per cent in 1926, lations, the United States has been using them to enhance its own industries. Foreign trade interests of the nation, as evidenced by the actual flow of commodities, had become concerned even before the outbreak of the war with the exportation of manufactured wares and with the importation of industrial materials and of special tropical and semi-tropical foodstuffs not produced in appreciable quantities at home. Under these conditions the time was ripe as the war came on for a marked commercial expansion into South America.

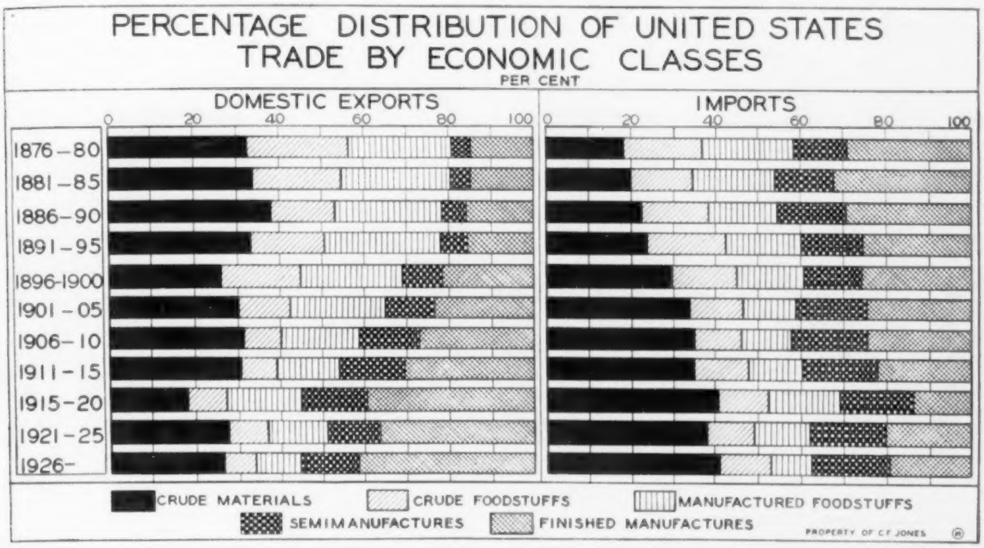

FIGURE 4.—During the past half century the United States has become more truly an industrial nation. The exports of finished manufacture have increased from 14 per cent in 1876–80 to 41.5 per cent in 1926; semi-manufactures 4.5 to 13.9, while crude foodstuffs decreased from 23.9 to 7.1 per cent and manufactured foodstuffs from 24.4 to 10.7 per cent. On the other hand, the imports of finished manufactures decreased from 29.4 per cent to 19.8; manufactured foodstuffs from 21.5 to 9.4 per cent; while the foreign purchases of crude industrial materials increased from 18 per cent to 40.5. Thus in the industrial expansion of the United States during the last fifty years the exports of finished manufactures have increased at the same rate as the imports of crude industrial materials.

and crude materials from one-third of the total in 1875 to one-fourth in 1926 (Fig. 4). The shipments of beef alone dropped from 350 million pounds in 1900 to practically nothing in 1913; they rose again during the war, but decreased soon after to almost none. On the other hand the imports of crude materials rose in the same period from 18 per cent of the total to 40.5 per cent.

Thus instead of sending supplies abroad to support manufacturing popu-

In the early stages of the war, while the United States remained neutral there was a reduced commerce both in volume and value, especially in shipments to that continent. The leading South American republics were passing through commercial and financial crises which had already reduced their foreign purchases. Then the war involving all the major powers of Europe, which had taken most of the exports and supplied much of the import trade of South America, accentuated the

difficulties. Commerce of many countries was cut in half; the vast producing sections were without an outlet for their produce; negotiations for loans in Europe ceased as none could be secured; immigration ceased; important projected public improvements and vast private enterprises were suspended; thousands of men were thrown out of employment; industry was temporarily paralyzed; moratoriums were declared for a few days and then extended for months. But in some lines the paralysis of trade did not last long; cereals, meat, wool, sugar, and copper were demanded in greater and greater quantities as the war progressed. However, for many products of South America the only hope of a market was in the United States.

The shipments from South America to the United States rose from 220 million dollars in 1914 to 760 million in 1920, the peak in the movement. While a considerable proportion of this increase must be accredited to the highly inflated prices prevailing up to 1920, the volume movement of commodities mounted greatly. Coffee came from Brazil, Colombia, and Venezuela in constantly ascending degree; hides from Brazil trebled in two years, those from Argentina and Uruguay advanced five-fold; in two years the movement of wool and the cacao receipts doubled; in spite of an abundance of corn in the United States, it took part of the big surplus of Argentina; a new market for flaxseed in the United States benefited Argentina greatly. Bolivian tin, which had all gone to Europe in the form of concentrates or raw material, found a market in a new smelter established on the coast of New Jersey; substantially all the output during the war came to the United States. Nitrate shipments to the United States more than doubled in three years for use as fertilizers and war materials. Copper imports from Peru and Chile increased

FIGURE 5.—The shipments of copper from Peru and nitrates and copper from Chile have been significant in increasing the traffic of the west coast of South America through the Panama Canal to the United States. The Oroya Smelter of the Cerro de Pasco Copper Corporation, an American concern, at Oroya, Peru, handles most of the copper of Peru and one-third of the copper exports from South America; nearly all the output from this plant goes to the United States.

TABLE I

SOUTH AMERICAN TRADE WITH PRINCIPAL COUNTRIES

(Figures in per cent of total)

Three-year Average	*United States*	*United Kingdom*	*Germany*	*France*	*Total of Four Countries*
		Imports			
1911–13	16.0	28.3	18.2	8.7	71.2
1915–17	37.3	22.3	....	4.8	64.4
1923–25	26.1	22.7	12.2	6.2	67.2
		Exports			
1911–13	18.3	23.2	13.5	9.0	64.0
1915–17	36.0	21.3	....	9.8	67.1
1923–25	25.6	20.7	7.7	7.6	61.6

greatly. Many other sections of South America benefited by the purchase of their staple products for which the European market had become restricted

On the other hand, South American merchants, after European stocks of goods were exhausted turned to the United States for manufactured wares, prepared foodstuffs, and some raw materials. The most significant gain in shipments to South America as a whole came in textiles, especially medium-grade to cheap cotton textiles suited to the purchasing power of a majority of the people. The shipments of mining and agricultural machinery, tin-plate, and petroleum products increased greatly, but the movements of iron and steel products generally and railway materials particularly grew slowly because the United States had to supply European belligerents and because little railway construction was being carried out in South America. England's inability to supply sufficient coal resulted in heavy imports from the United States by Argentina, Brazil, Uruguay, Chile, and Peru, the movement to the latter two countries being aided by the opening of the Panama Canal.

The completion of this major engineering project gave the United States a distinct advantage for trade with the west coast. It rearranged the trade routes of western Colombia, Ecuador, Peru, and all of Chile except the grazing region of Punta Arenas and Tierra del Fuego. Receipts of products of the west coast increased from one-tenth of the total imports of South America in 1910 to one-fourth of the total in recent years (Fig. 5).

This war trade advance of the United States in South America represents a remarkable development in view of the war organization of world shipping, lack of transportation facilities to South America, and the absence of an American merchant marine. Even after due allowance is made for inflated war and post-war values the United States showed increases in percentages as well as in quantities and total values in the South American commercial field, an evidence of real gain in spite of marked decreases during the world depression of 1921 and 1922.

The decrease of one-half in both shipments and receipts of the United States with South America in the years following 1920 resulted from a number of factors: the highly inflated prices of 1920 which gave the impression that the volume of trade, compared with previous years, was larger than was the case; the overstocked markets throughout South America, which resulted from feverish buying in 1919 and 1920; the steady deflation of prices causing merchants to restrict purchases to a minimum in the expectation of lower prices; the appreciation of the United States dollar; and competition from European countries which expected to see the often-called mushroom business of United States concerns return to pre-war levels, and which confidently expected to regain their former position in the trade (Table I).

However, the looked for wholesale replacement of United States goods by those of its former leaders in most South American markets did not materialize. On the contrary, the United States after

TABLE II

THE TRADE OF THE UNITED STATES WITH SOUTH AMERICA BY ECONOMIC CLASSES

	Millions of Dollars								*Per Cent Each Class Makes of the Total*			
	Domestic Exports				*Imports*				*Domestic Exports*		*Imports*	
Class	*1905–09*	*1910–14*	*1921–25*	*1925*	*1905–09*	*1910–14*	*1921–25*	*1925*	*1910–14*	*1921–25*	*1910–14*	*1921–25*
SOUTH AMERICA	74	121	294	400	148	207	421	519	100.0	100.0	100.0	100.0
Crude materials.	1	3	8	6	57	79	131	146	2.1	2.6	38.1	31.2
Foodstuffs......	9	13	26	38	73	99	206	281	10.9	8.8	47.8	49.0
Semi-manufactures......	12	22	46	65	17	27	78	90	18.2	15.7	13.0	18.5
Finished manufactures......	53	83	214	291	1	2	5	2	68.8	72.9	1.1	1.3

two years of depression came back as strong as ever. Exports to South America increased 175 million dollars from 1923 to 1926, and the imports from South America rose almost 270 million dollars from 1921 to 1926. In the percentage of the total commerce of the continent the United States stands far in the lead, in spite of many conditions favoring interchange of produce with European countries. An analysis of these conditions and then the bases of trade with the United States with the resulting flow of commodities will explain why the United States has entered the South American commercial field to stick and to increase its advantages in that part of the world.

In the first place, the culture of South America has always been essentially European. The United States and South America are not spiritual cousins. The United States citizen has far more in common with the British, Germans, Scandinavians, French, and Dutch. The basic South American racial, mental, and temperamental affinities lie with Spain and Portugal. The large German colonies in Brazil and Chile, the great numbers of Italians in the southeastern part of the continent, and the British business man and trader in all parts coupled with the commercial programs of the European countries during the half century preceding the World War gave exceedingly strong bonds of trade. Also European countries needed the raw materials of the farms, ranges, forests, and mines of South America; in turn South America required manufactured wares of all kinds from the advanced industrialized districts of Europe. Under these circumstances it is not expected that the people of South America will quickly abandon European social and commercial ties, unless special advantages grow out of other connections; but that is just what is happening all over the continent.

BASES OF PRESENT TRADE

The natural bases of trade that have laid the foundation for larger interchange of goods with South America and many developments and various changed conditions since 1910 have strengthened the position of the United States in its competition for the commerce of this section of the globe. Differences in climate, resources, and stage of industrial development constitute the chief bases of trade between the north and south portions of the western hemisphere.

The principal purchases of the United States in this field consist of tropical and semi-tropical foodstuffs and crude raw materials; these two classes contribute 80 per cent of the total receipts; and semi-manufactures, chiefly minerals, add another 18½ per cent, leaving only 1½ per cent for finished manufactures (Table II).

In the first class coffee, cacao, bananas, and sugar, none of which is produced in this country in large quantities, comprise the bulk of the movement. The people of the United States will have their several cups of coffee per day and consequently they look to the plateau of east-central Brazil, and the highlands of Colombia and Venezuela, for most of the supply (Fig. 6). Coffee, a tropical or

semi-tropical commodity, alone constitutes more than one-third of the total purchases. The United States consumption is the determining factor in marketing the output of these regions. Also this nation takes a big share of the cacao from Bahia and Ecuador, and of the bananas from Colombia.

Crude raw materials for the manufacturing plants of the United States include hides and skins from all portions of the continent, wool, especially from Argentina and Uruguay, linseed from the Pampas, rubber from the tropical forests, quebracho extract, vegetable ivory, manganese, bauxite, petroleum, asphalt, and a variety of minor products —all move as a result of differences in development, climate, or resources, an expression of the advancing industrialization in this country. Not long ago the demands for several of these products were satisfied by the domestic output, but now this nation has become a significant factor in marketing most of them.

Semi-manufactures composed chiefly of copper, nitrates, iodine, and other minor products of the mineral industry come principally from the Andean section of the continent through west coast ports and the Panama Canal. The United States leads all countries in the consumption of these commodities. However, as before the war, the United Kingdom dominates the tin trade of Bolivia, taking 98 per cent of the latter's total exports because of its political, financial, and economic control of the world tin industry. The expansion of the United States interests into the copper, nitrate, and other mineral industries of western South America emphasizes the increasing dependence of American factories upon foreign raw materials (Fig. 7).

Of the total shipments to the United States of finished manufactures, Panama hats and others comprise only 1½ per cent, or amount to only 2 million dollars, an expression of the lack of large manufacturing industries in South America, which is new from an industrial point of view, and which lacks coal, labor, capital, and technical skill for a great development along this line. Consequently, the South American nations exchange foodstuffs and raw industrial materials for manufactured wares and prepared foods.

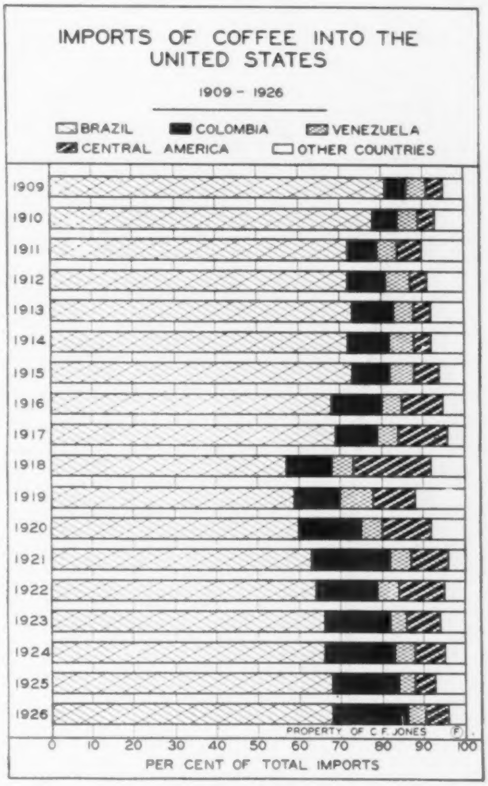

FIGURE 6.—Coffee, the leading export commodity of South America making up 16 per cent of the total, constitutes almost one-third of the total purchases of the United States in South America. With repeated coffee valorization schemes in Sao Paulo since 1906 the receipts from Brazil have decreased from 82 per cent of the total coffee imports to 68 per cent, at the same time those from Colombia increased greatly.

The situation with reference to exports to South America represents the reverse of the preceding movement. Crude materials comprise only 2.6 per cent of the total, foodstuffs largely manufactured or prepared 8.8, semi-manufactured articles 15.7, and finished manufactures, 72.9 per cent of the total (Table II). Thus more than nine-tenths of the shipments to South America consist of the

FIGURE 7.—While the United Kingdom dominates the tin trade of the world, even the export movement from Bolivia, investments of United States capital, activities of American mining men and engineers in the development of low-grade copper deposits of Peru and Chile give the United States control of the enormous output of copper from Cerro de Pasco, Chuquicamata, Potrerillos, and Braden and of the markets for machinery, equipment, and supplies of these great copper camps. A general view of the camp at Potrerillos, Chile, a small city of 5,000 people concentrated in a barren desert region for one raw industrial material—copper. This is the newest large scale copper development in South America.

products of numerous manufacturing plants, expressing the great difference between the United States and South America along this line. The one-sided development[1] of most South American nations affords a most fertile field for manufactured wares of many kinds. The increasing industrialization of the United States places it in an excellent position to supply many of the wants of various sections of the continent.

While the manufactured wares include almost everything from hairdresser's notions and barber's supplies to huge ore-crushing machines so massive that several railway cars are required to transport the crusher from the factory to the port, a few major classes of goods comprise the bulk of the movement. General iron and steel products and railway supplies for all regions, agricultural machinery especially for the River Plate region and Brazil, mining machinery for the Andean mountains and plateaus, and automobiles to various sections comprise more than two-fifths of the total. Cheap to medium-grade cotton textiles from the States clothe the Indian, Mestizo, or white alike from Panama to the Horn and from beautiful Rio to sweltering Guayaquil. Kerosene lights the simple lamps of the innermost recesses of the Andes and of the distant headwaters of the Amazon, while a considerable share of the American automobiles (the United States supplies about 98 per cent of all cars purchased in the continent) burn gasoline shipped by American concerns. In addition Puget Sound lumber, Massachusetts and New Jersey chemicals, and Minneapolis and Buffalo flour enter

[1] A few products completely dominate each country: Argentina, grains and animal products; Uruguay, animal products; Brazil, coffee, cacao, and animal products; Venezuela, coffee, cacao, and petroleum; Colombia, coffee; Ecuador, cacao, coffee, and tagua; Peru, cotton, sugar, copper, and petroleum; Bolivia, tin and other minerals; Chile, nitrates and copper; in each case the commodities named comprise from about two-thirds of the total exports to as much as 95 per cent—refer to graphs or exports for each country.

TABLE III

THE TRADE OF THE UNITED STATES WITH SOUTH AMERICA BY COMMERCIAL REGIONS

Region	*Exports in Millions of Dollars*			*Imports in Millions of Dollars*		
	1910–14	*1921–25*	*1926*	*1910–14*	*1921–25*	*1926*
Caribbean	13	44	92	23	66	115
West coast	23	60	88	36	104	110
East coast	85	193	263	148	251	343
Total	121	297	443	207	421	568

many parts of the continent. The American typewriter clicks in the offices of the city, in the country, and in the remote mining camps.

In spite of nearness of the north coast to the United States and easy access to the west coast through the Panama Canal, the trade of the Atlantic region outstrips that from the other two combined (Table III). A relationship that is true also of the commerce with other countries, for the southeastern portion of the continent between Bahia and Punta Arenas contributes more than two-thirds of the exports and consumes an equal proportion of the imports. It emphasizes the dominance of temperate and subtropical agricultural lands over the tropical lowlands and all the mineral districts. This region has vast continuous fertile areas adjacent to the sea and supporting excellent forage or ready for the plow and the reaper (Fig. 8); it holds 70 per cent of the population of the continent and 90 per cent of the people in which the European element predominates; and more than three-fourths of the railway mileage of the continent connect this area with excellent ocean and river ports.

AIDS TO COMMERCIAL EXPANSION IN SOUTH AMERICA

In addition to the natural bases of trade and the continued industrialization of the United States which paved the way for the preceding interchange of commodities, the southward march of capital and men, the campaign against tropical diseases and insects, the organization of the greatest trade information bureau the world has ever known in the Bureau of Foreign and Domestic Commerce with its representatives in every important trade center of the continent, the development of American shipping and communication, and the increasing competitive ability of the United States compared to that of its chief competitors in the field have all aided materially in the recent commercial advance of the United States in South America. However, to avoid undue emphasis being placed on the expansion in South America, it should be noted that the growth of trade here is not much greater in proportion than that in other parts of the world. While the exports to South America have increased from 3.3 per cent of our total exports in 1875–80 to 9.2 per cent in 1926, the imports from South America in percentage of total decreased slightly, in spite of a nine-fold advance in value.

No stronger trade bond exists than huge investments in the development of the resources and transportation facilities and in the securities of foreign countries. The outbreak of the war caused an immediate change in European investment markets; the exportation of capital from the warring nations ceased and South American countries, which had secured much of their capital from Europe, were made dependent upon the United States. Previous to 1914, the international money of the world consisted of the pound sterling and London was the financial center. Today the dollar is the best-known currency and the one which stands like a rock in the flood of shifting money. The dollar is gold, and gold is the dollar; they are interchangeable one with the other anywhere at any time. Not only that, but the surplus gold of the world now flows to the United States; New York has become the new

FIGURE 8.—The vast level plains of Argentina and Uruguay constitute the chief surplus grain and meat region of the world; the Pampa free from stones and stumps, with a fertile soil, gentle relief, sparce population, and a location on the banks of the Parana or the shores of the sea, favor the extensive production of cereals for export. (Courtesy of H. G. Olds.)

and greatest center for the investment of the surplus funds of the world and now shares with London the responsibilities that go with that position—not a small achievement for a country and its bankers in a little over a decade, when the financial organization of the European centers was the growth of centuries. Before the war British investments in South America totalled about 5 billion dollars, those of France 1½ billion, and Germany slightly less than those of France; but these amounts have not been increased since the war, and may not for a long time, because of the debt burden under which Europe is groaning.

On the other hand, United States' investments in South America have increased from a few hundred million in 1914 to about 2 billion dollars at the end of 1926. While they are considerably below the British figure, they have entered many enterprises that affect vitally the exports and imports of the continent. In the Andean regions the Americans are moving the mountains not with faith, but with energy, machinery, and capital. The copper mines at Chuquicamata, Braden, and Potrerillos and some nitrate fields represent an investment of 400 million dollars, tin properties in Bolivia 30 million, and copper in Peru 40 million (Fig. 9). On the east coast, American packing plants dominate the industry and represent an investment of 80 million in Argentina and 35 million in Brazil. Millions more have entered the petroleum field of the northern countries, and city, state, and government loans throughout the continent; in Colombia alone in recent years 25 million in bonds for railway developments and public improvements were let in the United States. These call for machinery, supplies, and men from the country. The road improvement program, oil developments, railway extension, and mining activities constitute a boom for many parts of South America; with European countries out of the money market, enterprises must look to the United States for the necessary capital. United States branch banks in the leading commercial centers aid all business activities of Americans in South America; the finest office building in Buenos Aires belongs to the First National Bank of Boston.

With the rising flood of capital have gone increasing numbers of men, who produce the commodities United States industry needs and who look to the home country for all supplies in various lines of activity. In addition to the engineers and business men connected with the mineral industries of Chile, Bolivia, and Peru, are the cattlemen and packers, an American at the head of the Department of Mines of the Bolivian government, one directing all irrigation works in Peru,

another constructing a 10 million dock system at Lima, the men in the United Fruit Company, and those in oil development work. Dr. Pearson, an American engineer, gave light, heat, power, and telephone communication to Rio de Janeiro, a group of men completed the Tupiza-La Quiaca section of the Argentine-Bolivia railway, after others gave it up, and a company built water works and sewer systems in five leading cities of Uruguay, one reorganized the statistical bureau of the Argentine government, and another placed the banking system of several countries on a business basis, not to mention the permanent have placed their shoulders to the wheel of progress.

To all these activities must be added the trade force of the Bureau of Foreign and Domestic Commerce, both in Washington and in all parts of South America. This organization has the latest information on any commodity, any region, and any industry and has at its disposal, technical and practical advice of incalculable value to the new or old trader in foreign lands.

Of no less value than the preceding factors to our commercial advance has been the development of shipping and communication with South America.

FIGURE 9.—Mule carts loaded with Oregon structural timbers enroute from the Antofagasta-Bolivia railway at Eucalyptus over a cart and automobile road built at great expense for 60 miles across the plateau and over the eastern range of the Andes at 16,000 feet, to the Guggenheim tin mill near Pongo, Bolivia, one of the newest and most modern plants in the world located at 12,000 feet above the sea.

representatives of many manufacturing concerns. The United States resident merchant in South American fields no longer remains an exception to British and German merchants who form vital factors in their trade connections.

Furthermore, the American campaign against tropical diseases and insects, through the activities of the Rockefeller Foundation and other organizations, has created of veritable pest holes beautiful places in which to live. It has practically eliminated yellow fever, and by it hookworm and malaria have lost much of their terror. Beggars cured of hookworm or relieved of the ague of malaria have renounced their calling and Before the war no regular American line served either the west or the east coasts. British lines practically monopolized the east-coast business, and much of that of the west coast. Now United States vessels operate to all parts of the continent affording faster service than British vessels—18 days from New York to Buenos Aires by the Munson Line or 20 days from New York to Valparaiso by the Grace Line. During 1925 the Munson Line handled more than two-thirds of the passenger traffic between New York and Brazilian, Uruguayan, and Argentine ports. On the whole, the merchant marine of the United States, coastwise and sea-going, stands at approximately

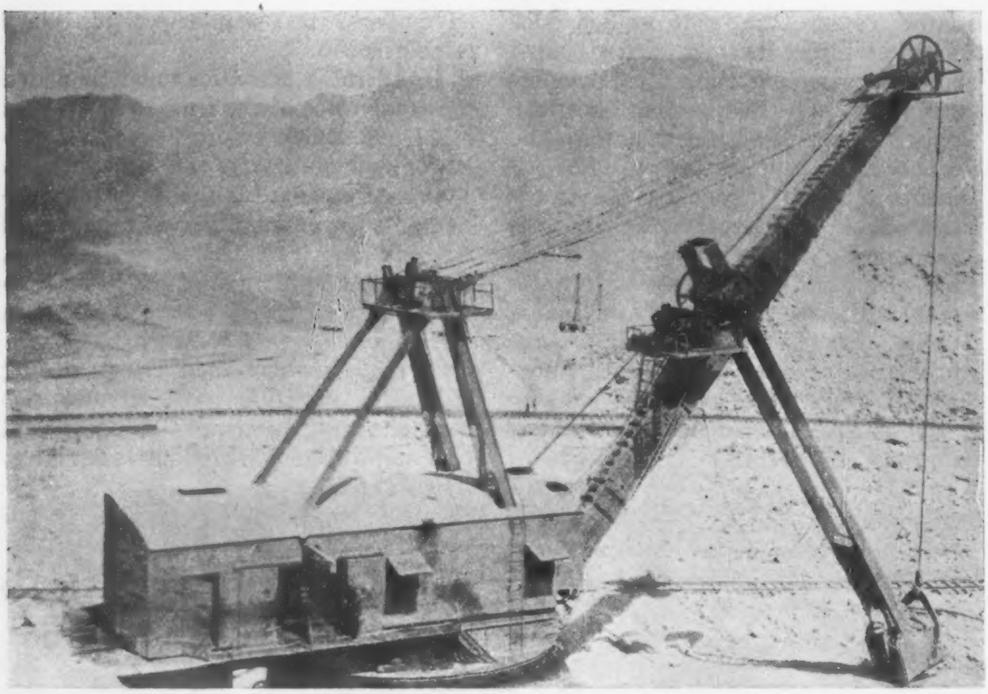

FIGURE 10.—The United States ships a great variety of iron and steel products to all parts of South America. Among the more important items are mining machinery and equipment for the Andean regions, drilling machinery and pipes for the oil fields, railway supplies for many sections, agricultural implements for Argentina and Brazil and a host of other materials for diverse regions. An 18-ton shovel equipped to lift eight cubic yards of copper ore at one bite and drop it into a railway car. Chuquicamata, Chile. The standardized production of machinery of this type is a prime factor in aiding United States trade with South America.

26,400 vessels of 17,400,000 gross tons, compared with about 19,500,000 tons for the United Kingdom. While British shipping for all South America ranks ahead of that of the United States, in many ports American shipping is on a par with that of the British, and American vessels hold their own in the face of intense competition.

Closely allied to ocean transportation in aiding growth in trade is cable service and the all-important matter of news, since people form their ideas of countries chiefly from what they read. Before the war, European-owned cables in all *Latin-America* totaled 25,000 miles; the mileage of the United States amounted to only 14,000. Today the latter is 24,000 while European cables remain at pre-war levels. For years the reports of all happenings in the United States, whether prize fights or national elections, went to Europe and then were filtered for South American reception through various agencies with clients in the southern continent. Now through the activities of the United Press, news exchanges are made from day to day without any foreign flavor. If the United States has been slow in these fields it has been a pioneer in the air—illustrated by the recent aeroplane tour of South America and in the employment of advertising and the distribution of catalogues.

So significant are the developments in all these aids to commercial expansion that the American business man today alights from a United States vessel, proceeds to his own branch office or to the establishment of an American firm for detailed information on his line, transacts all financial matters through well-equipped United States banks, lunches or dines at an American club, and during

his leisure hours tours the city in an American automobile, plays golf on an American course or reads the daily news from home received through the United Press. In these aids to trade, the United States stands on a par with the United Kingdom and Germany or is approaching that position. The extent of the United States' advance in the South American commercial field then depends upon its ability to purchase South American produce and to supply that continent with manufactured wares in competition with the United Kingdom and Germany, its chief rivals. The competitive ability, other things being equal or nearly so, depends largely upon the primary conditions of consumption and the production of the basic iron and steel goods, textiles, petroleum, and coal, which comprise the chief imports of South America (Fig. 10). How do these countries compare with the United States in these respects?

THE UNITED KINGDOM AS A COMPETITOR IN SOUTH AMERICAN TRADE

In spite of an early start, large numbers of enterprising British in the field, investments two and one-half times as great as those of United States' interests, an extensive merchant marine with ships plying all seas, and a greater dependence than the United States upon foreign regions for foodstuffs and raw industrial materials, and for markets of manufactured wares, the trends in the basic manufacturing industries during the past half century indicate that the competitive ability of the United Kingdom may have reached its peak and appears to be on the decline.

THE IRON AND STEEL INDUSTRY

Iron, coal, and steel, with the products to which they give rise, lie at the base of the modern commercial world. The lengthy girders for bridges or for "skyscrapers," the massive locomotives, railway rails, battleships, combined reapers and threshers, delicate surgical instruments, and even the hairspring of the watch are all made of iron and steel by the aid of coal. No better index to the economic strength and competitive power of a nation exists than the trends in its iron industry.

The exports of iron and steel goods, including machinery, tools, implements, and cutlery, comprise one-fifth of the total exports of the United Kingdom; they make up the same proportion of the total exports of the United States. Yet, these figures fail to indicate the real, the vital importance of the industry in competition for foreign markets. It was the possession of iron and coal in close proximity along with other advantages that made the industrial leadership of England, attained before our fathers were born, an accepted immutable feature of the world. But in the United States, the completion of the Sault Ste. Marie Canal, which made it easy to bring cheaply the high-grade ores of the Lake Superior region to the coal fields in western Pennsylvania, was the starting point of the rapid advance of the United States.[2] The seizure of Alsace-Lorraine, with its enormous iron ore deposits, during the Franco-Prussian War, marked the beginning of Germany's meteoric rise.[3]

In 1880 the United Kingdom mined half the iron ore of the world; in 1925 its output was less than one-tenth of the total. It has become dependent upon foreign deposits for half of its pig-iron output and steadily leans more and more upon them. Its 450 million tons of medium-grade ores at the present rate of output will last only some thirty years. France today has six times as much high-grade iron. The United States holds seven times as much in known high-grade reserves and ninety to one hundred times in potential reserves.

Since 1880 the production of pig-iron has not even kept pace with the increase

[2] In the decade following the opening of this canal, pig-iron production in the United States increased more than three-fold, and the output of steel almost five-fold.

[3] The output of pig-iron in Germany increased from 1.3 million tons in 1870 to 3.6 million in 1880; in the same decade steel production increased from 165,000 tons to 700,000.

TABLE IV

PRODUCTION OF PIG-IRON

(Millions of long tons)

	1800	1850	1880	1900	1913	1923	1925
United States	.05	.5	3.94	13.7	30.9	40.3	36.8
United Kingdom	.2	2.2	7.7	8.9	10.2	7.4	6.2
Germany	.04	.4	3.6	8.3	16.4	4.8	10.5
France	.06	.57	1.7	2.6	5.1	5.3	8.3
World	.46	4.7	17.9	39.6	77.5	65.9	72.4

in population; it rose from 7.7 million long tons in that year to 10 million just before the war; the output of 1925 was only little more than half that before the war (Table IV).

Compare this with the production of pig-iron in the United States from less than 4 million in 1880 to 40 million in 1923 (36.8 million in 1925), from 22 per cent of the world's total to 60 per cent (1923; 51 per cent in 1925).

A similar situation exists in the production of steel; the output of the United Kingdom stands at pre-war levels, while that of the United States has increased almost five-fold during the past twenty-six years. The latter produced in 1926 55 per cent of an estimated world total of 88.3 million long tons (Table V).

England's iron and steel industry, affected by over-conservatism of management, opposition of labor to new improvements, reduction of output, general reversion from capitalistic production, decreasing supply of ore, the rising cost of coal, a small static domestic market with few demands for new types of tools, implements, and machines, shows marked stagnation, and its products face replacement in foreign markets. In contrast to this in the United States, the large domestic market, standardization of machines, the interchange of parts, and the constant demand for improved technical methods, promote the general high quality and the quantity output of American products, which gain recognition the world over. American automobiles dominate the automobile markets of the world, and United States binders and combined reapers and threshers harvest most of the wheat of the world even in Argentina, a country of strong British ties, and in the far-away Commonwealth of Australia, where British machines should dominate, if anywhere (Fig. 11).

Consequently, in respect to the iron and steel industry, one of the fundamental bases of interchange of goods with South America, the United Kingdom, compared to the United States, exhibits an appallingly weak position.

TABLE V

PRODUCTION OF STEEL

(Millions of long tons)

	1850	1880	1900	1913	1923	1925	1926
United States	.005	1.2	10.2	31.3	44.9	45.4	48.2
United Kingdom	.05	1.3	4.9	7.6	8.4	7.3	3.5
Germany	.006	.7	6.5	17.3	6.2	12.1	12.2
France	.008	.4	1.5	4.6	5.0	7.2	8.3
World	.071	4.2	27.8	74.7	73.6	87.4	88.3

COAL

Coal was a primary factor in bringing about the industrial revolution by furnishing the power for machinery and fuel for smelting iron in huge quantities; its early exploitation caused England to forge ahead of any other country in the world.[4] In addition, the location of

[4] Today it assumes even greater importance in industry than it did in early days owing to the lack of large water power resources in the United Kingdom. About half the coal consumed in the United Kingdom is used for industrial purposes. Ninety per cent of its total engine capacity depends

large deposits of high-grade steaming coals near the sea at Newcastle and Cardiff aided greatly in building up the British merchant marine and foreign trade. An importer of heavy bulky goods and an exporter of chiefly manufactured wares of high value but of relatively small bulk, the United Kingdom has always filled the vacant space in outgoing ships with coal for nearly all parts of the world at cheap freight rates. The exports of coal mounted from 5 million tons a year in the 1850's to 95 million tons including bunker coal in 1913; they dropped during 1921 to one-third that amount, but increased again to almost 100 million in 1923; 1926 exports totalled only 27½ million tons, including bunker coal.[5]

Regardless of temporary fluctuations, the trend of the past thirty years in the coal industry indicate that the United Kingdom no longer holds the major advantages it did for nearly a century (Table VI). Its total output stands below pre-war levels, not considering the extremely small production of 125 million tons in 1926. Its proportion of the world total decreased from about 90 per cent in 1800 to 29.3 a century later and to 18 per cent in 1925. In addition, the industry has been accompanied by an almost unbroken decline in the yearly output per laborer from nearly 319 tons in 1880 to about 200 in 1925. In contrast to that the yearly production per man in the United States rose from 400 tons to almost 800 tons in the same period. Machinery is used in the production of more than half the bituminous coal of the United States and in about 12 per cent of that of the United Kingdom. Furthermore, the cost of producing a ton of coal in the United Kingdom is nearly double that in the United States.

FIGURE 11.—The large areas of fertile level land of Argentina favor the extensive use of agricultural machinery. The name on the push-binder indicates its origin—The International Harvester Company of America, the company which has done much to meet the needs of this fertile land of sparse population for labor saving machines. (Courtesy of International Harvester Company.)

These fundamental differences of production, while influenced by economic and social factors, are based primarily on the character of the coal deposits and their distribution. The chief American coal fields, near the center of manufacturing activity and not far from the sea, have no deep mine shafts as in the United Kingdom; massive deposits, thinly capped, trenched by rivers, allow the coal to be reached by shallow borings or by

upon coal as fuel; 95 per cent of its electric dynamos are driven by coal engines.

[5] The high figure of 1923 resulted from difficulties in the fields of Europe and those of the United States, while the low figure of 1926 was caused chiefly by the British coal strike and coal stoppage.

TABLE VI

COAL PRODUCTION

(Millions of long tons)

Countries	*1800*	*1820*	*1850*	*1875*	*1900*	*1913*	*1920*	*1925*
United States	.18	.45	7.0	48	240	509	563	522
United Kingdom	9	11.2	56.0	135	225	287	233	246
Germany	.53	1.3	6.1	48	150	191	141	130*
World	10.3	15.4	72.3	260	800	1,328	1,298	1,346

* German production for post-war years includes output within present frontiers and only bituminous coal. If brown coal (lignite) be added, the figure for 1925 is 267,000,000 long tons.

adits from the valley sides. The coal drawn from the mine up gentle slopes or run down by gravity is dropped into barges or onto railways that follow the terraced banks of the rivers. Access could not be easier and the thick, uniform, and rather continuous seams favor the employment of mining machinery on a large scale.

Finally, the reserves of 190 billion tons in the United Kingdom are insignificant compared to 3,500 billion tons in the United States. Also British coal meets keener competition in various sections of the world; Indian coal in southern Asia, Australian coal in the Pacific, Natal coal in South Africa, and American coal in the West Indies, Canada, and parts of South America. All these considerations combined force the conclusion that British coal no longer presents any great advantage from a competitive point of view, either in industry as a whole or in furthering its foreign trade and shipping. The restriction of the export market indicates a decline in the competitive advantage in manufactured wares, for a decrease in the exports of coal increases the burden which the domestic consumption must bear, which is reflected in all industries.[6] As in the past, coal remains an index to prosperity in the textile industry as well as in the iron and steel industry.

TEXTILES

For generations the cotton-textile industry has been Britain's leading trade concern. It has supplied 20 to 30 per cent of the nation's total exports, consumed 10 per cent of the imports in the form of raw cotton all of which comes from overseas, practically monopolized until recently the entire foreign field, especially the South American market, and knows no competitor in the finest grades of goods. United States concerns may never equal the British when it comes to quality. It is one thing to make a cloth which will adequately cover the body of the South American Indian or Mestizo, and another thing to produce a cloth to meet the esthetic demands of the Argentine or Chilean woman of fashion (Fig. 12).

The strength of the British industry, favored by all the advantages of an early start, cheap and highly skilled labor, individual manufacturing technique, and cool, moist climate, has been in the manufacture of a vast quantity of goods for foreign consumption and a highly organized trade machine. Eighty-five per cent of the output goes into foreign markets. During the latter part of the nineteenth century with the dominating position in production and with the world open to its output, the whole industry rested on its reputation, made few improvements, passively witnessed the unionization of its labor to a high degree, and consequently failed to make the best of its advantages.

While the United Kingdom has 57 million spindles and the United States only 38 million, the American spindles turn out twice the weight of yarn produced in England. In this country 90 per cent of the spindles consist of ring spindles; in the United Kingdom only 25 per cent;

[6] This principle was vividly illustrated in 1926 when the United Kingdom had to import 20 million tons of coal; not one industry remained unaffected, by greater costs of operation.

the ring spindle turns out twice as much yarn as the old type "mule" spindle. The American ring spinner has charge of 750 to 1,000 spindles, the English girl, from 400 to 800, and the speed of her machine is lower. "The American weaver tends twice as many looms as the English weaver on the same type of machine."

Trends since 1900 in various sections of the world have robbed the British of fields for about 15 per cent of the output. The production in all these new regions (the new districts of the United States are not exceptions) consists of cheap goods especially suited to the buying power of most of the people of South America. The severity of competition in medium and coarse lines and the restriction of raw materials have forced the United Kingdom to capitalize its peculiar advantages

FIGURE 12.—In spite of small purchasing power of the highland Indians of South America, they have special requirements for articles of clothing. The native flocks of the mountains and the domestic weavers furnish a good share of the clothing of these simple folk, yet considerable quantities of textiles are purchased from overseas. The British for a long time in the market with various grades of goods have been able to dominate the textile trade until recent developments in the world forced the British mills to specialize more and more upon expensive high-grade goods, thus allowing new textile districts to take over much of the trade in the cheaper coarser fabrics.

markets they dominated for a long time. Japan controls the market for cheap goods in the Far East; India, which took 40 per cent of the total exports of cotton goods of the United Kingdom in 1890, now manufactures more than half of its requirements; Brazil, the largest market for cheap textiles in South America before the war, now makes nine-tenths of its consumption; the United States, in addition to supplying the largest single market in the world at home, now looks to foreign of climate and skilled labor and to concentrate more and more upon fine-quality goods, which enjoy a narrower market than the cheaper grades. In the woolen industry similar trends are exhibited. While the value of the high-grade goods may be greater for a while than a large output of cheaper lines, the fact remains that the United Kingdom, crowded by new textile regions, turns away from quantity, capitalistic production and supplies a decreasing, restricted market, com-

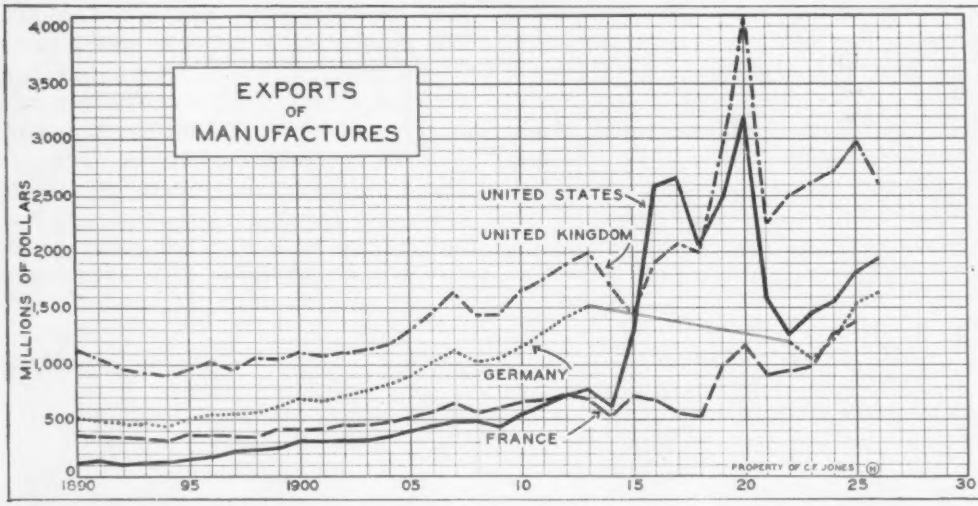

FIGURE 13.—In 1890 the exports of manufactures were valued at only one-third of those of France; Germany and the United Kingdom were far ahead of this country; but the exports of manufactured wares rose from about 100 million dollars in 1890 to 800 million in 1913, surpassing those of France. Then, after a temporary drop in 1914, they shot up to almost 2,700 million in three years, surpassing those of both Germany and the United Kingdom. In recent years they have been well above those of France and Germany and the difference between those of the United Kingdom and the United States decreases, the United States exports of all manufactured wares increasing more than those of the British. With continued industrialization in this country, the shipments of finished manufactures will mount to higher levels. (The classification of British goods includes some semi-manufactured wares while those of United States are finished manufactures. If semi-manufactured goods be included the figures for recent years for the United States will approach those of the United Kingdom.)

pared to the industry of the United States.

These adverse trends, considered from the standpoint of competition in South American markets are further emphasized by the rapid rise since 1890 of the United States as an exporter of total manufactured wares compared to its chief competitor, the United Kingdom (Fig. 13).

From most angles of the iron and steel industry, coal mining, and textile manufacturing, the strength of the United Kingdom as a competitor appears to be on the decline.[7]

[7] Yet it must not be forgotten that British interests control the tin industry of the world, the rubber supply, the entire jute output, most of the nickel, asbestos, and smaller quantities of many other products. Also foreign raw materials and foodstuffs and overseas markets are more essential to the United Kingdom than to the United States. They are the sum and substance of the economic prosperity of the nation. The British cannot afford to release many of their South American markets even in the face of the keenest competition.

GERMANY AS A COMPETITOR IN SOUTH AMERICAN TRADE

Germany, entering the South American commercial field rather late, came forward at a surprising rate; with the unification, industrialization, and commercialization of the nation following the Franco-Prussian War, it built up in a third of a century a trade almost equal to that which the United Kingdom had taken three times as long to develop. From small beginnings in 1870 its trade in South America advanced to nearly 300 million dollars, almost replacing the United States in second position. But this remarkable—almost romantic from the viewpoint of persons on the outside, but exceedingly businesslike from the inside—commercial penetration of South America was nipped in the bud by the World War (Table I). While the Germans are making strenuous efforts to regain their former position, the trade is far below pre-war levels and they operate under many handicaps, that have a

direct bearing on their competitive ability.

The war cost Germany 27,200 square miles—13 per cent of its pre-war area—6½ million people, 20 billion dollars in national wealth, the Lorraine iron fields which supplied 60 per cent of Germany's iron ore in 1913, Silesian coal and iron, a third of its basic steel output, the Alsatian potash (8 per cent of the total), the Alsatian cotton industry, its vast overseas colonial holdings, good will in trading throughout the world, and more than half of its former merchant marine. In addition the mineralized Saar Valley is to be exploited by France under the League of Nations for fifteen years. Thus, as a result of the war, Germany lost many of the original factors which paved the way for its commercial ascent.

The loss of the iron reserves of Lorraine compels Germany to depend upon foreign sources for three-fourths of the iron required by its industry on a pre-war level. However, nearby Belgium imports 90 per cent of its iron, but the United Kingdom one-third. With the high-grade coking coal of Westphalia cheaply produced, the loss of the ore may not be a permanently serious handicap, unless France in its endeavor to foster domestic industries erects a trade barrier which the ores and steel cannot surmount profitably.

In spite of these great handicaps, the new Germany, undaunted, moves forward in its industrial progress and commercial expansion. It extracts the greatest possible amount of energy out of coal, oil, brown coal (lignite), and falling water. Its forests conserved with tender scientific care for generations yield valuable products. Its pig-iron and steel output in 1925 was back to two-thirds of that of 1913 even with restricted plants and lost resources (Tables IV and V). The production of coal amounted to 130 million tons as against 191 million in 1913, not including the utilization of enormous quantities of lignite for generating power and for industrial purposes. It still dominates the world in the dye and chemical industries. It controls nearly all the world's potash. It delves down into the earth and reaches up into the air to supply its impoverished soils with potash and nitrogen.[8] It has made of the whole nation through the use of brown coal, water power, and "science," a veritable human ant hill pulsating with industrial, commercial, and agricultural activity.

Compared to its industrial neighbors, the United Kingdom, Belgium, and Switzerland, Germany has distinct advantages from the standpoint of a food supply. Its per capita imports of foods amounts to only one-fourth to one-third of that of these countries. With the aid of science and fertilizers, the German has converted the bogs and sand dunes of Pomerania into fertile fields of rye and barley, the moraine deposits of the northern plain into the greatest potato belt of the world, and the Halle region into one of the most productive wheat districts of the world.

Furthermore, this nation of 60 million homogeneous people with skill, patience, and inventive capacity occupy the heart of northwestern Europe among the teeming millions of the continent. Its doors are open to water-borne traffic through the Rhine, the Elbe, the Oder, and an excellent network of canals; its huge manufacturing concerns have ready access to the sea, favoring foreign trade. In addition, "the German cartel system provides a keen cutting edge for the penetration of foreign markets." By this system goods may be sold at cut-rate prices in foreign markets and any losses incurred made up by higher prices in the domestic market. It serves as an effective wedge for opening up foreign markets in fields of keen competition. These great joint-stock companies combine all phases of the industrial and commercial life of the nation, and enter every part of the world with their produce.

With its trade organizations, specialization of industry by the use of science

[8] Before the war Germany was the largest consumer of Chilean nitrates, but now it takes practically none, and is looking about for a market for its surplus fertilizers.

to a greater degree than any other nation and by the employment of skilled, patient labor, even in the face of war handicaps and the loss of resources, Germany competes actively in the South American markets in many lines of goods, especially dyes, chemicals, hardware, and certain grades of textiles, and even iron and steel products, the latter two being the leading classes of imports of South America. The average monthly exports of iron and steel goods of Germany last year were almost four times those of 1923. And now with the *Continental Steel Entente*—conceived by German minds and put across largely by German influence—combining Germany, France, Belgium, Luxemburg, the Saar, Czechoslovakia, Austria, and Hungary into one great cartel with approximately one-fourth of the steel-capacity of the world, Germany, which has at the present time more than half of the capacity of the *Entente*, stands in a position to relieve the friction and competition that has existed since the war between the steel districts of continental Europe and to dominate the output of one-third (in 1926 the members of the *Entente* produced one-third of the world's steel) of the steel of the world. This sweeping combination of economic power and the amazing progress of Germany in other fields points to a keen competitive ability with the United States and the United Kingdom, its two chief rivals in South American markets, which remain more open and free of political hindrances to German commercial penetration than any other major regions in the world.

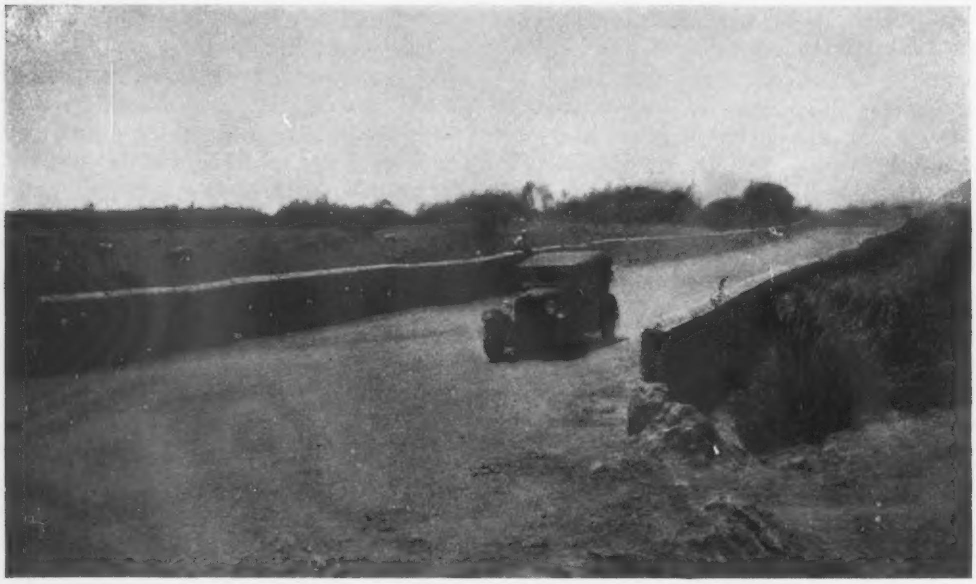

FIGURE 14.—In the coastal desert, the Chilean valley, the cold Andean mountains and plateaus, the tropical lowlands and plateaus, and in the temperate plains of the southeastern part of the continent American automobiles dominate. They have replaced almost completely cars of European makes first in the field. The Americans have taken the field by mass production of good looking standardized cheap, medium, and expensive cars suited to the tastes of any and all customers, by a well-managed advertising campaign, by the installment selling plan, and by the establishment of repair and service stations, even to the feature of "aere libre." European producers have not been able to compete in the automobile trade.

FRANCE AS A COMPETITOR IN SOUTH AMERICAN TRADE

While its portion of South America's total trade is below pre-war levels, France has advanced materially in some countries with special lines. Into South American marts from France poured before the war a steady stream of fine

wines, cosmetics, perfumes, lingerie, laces, furs, and fashionable gowns—high-quality luxury goods which embodied much talent, taste, and skilled labor. Lacking the coal of the United States, the United Kingdom, and Germany, for capitalistic production on a large scale, France made use of its high quality labor and produced goods which none of the major industrial countries duplicated. In these lines it had an open and free market. It still dominates the trade of all South America in these goods.

But the France of today is not confined entirely to so restricted a line of wares. In spite of the loss of one-fifth of its total productive population, extensive devastated lands, and factories, France stages an industrial renaissance. The recovery of the Alsatian cotton textile industry with 800,000 spindles and 45,000 looms[9] combined with that of the East gives France the leading cotton spinning and weaving industry of the continent. With a total of 9.5 million spindles France vies with Germany for third place as a world cotton manufacturing country. The destruction of the woolen industry of the war-torn sections was partly compensated for by that of Alsace (550,000 spindles). From the rejuvenated plants in some sections come quantities of cotton, wool, silk, and all these mixed, which have entered foreign markets. The progressive decline of the franc has stimulated the production of cheaper goods.

But the greatest development has taken place in another field. The restoration of Lorraine with its 560 million tons of known reserves of iron ore gives France control of 1½ billion tons of high-grade ore, the largest reserves in the continent; the coal deposits of the Saar Basin, estimated at 16½ billion tons, are to be exploited by France; also France has received from 12 to 7 million tons of coal annually from Germany as reparation deliveries from 1920 to 1926. All these factors, the unsettled conditions in Germany, and the declining output of the United Kingdom have given the French iron and steel industry a remarkable stimulus. Both the pig-iron and steel output of France today (1926) is almost double that of 1913; France now ranks as the third steel manufacturing country in the world; it supplies the home demand, exports to neighboring countries of Europe, and has begun to enter distant South American markets with steel products. Since France stands in a position similar to that of Germany after the war of 1870–71, can it duplicate the achievement of the Germany of that time?

It has been said frequently that "iron ore goes to coal," and even though France has regained the Lorraine iron deposits, it is in no better position to exploit the ores than before the war. However, it must be noted that before the war when Lorraine was a part of Germany and the huge steel concerns owned Westphalia coal and Lorraine ore, that more than half the ore was smelted locally. Out of 21 million tons of ore produced in 1913, 11.7 million were smelted in Lorraine furnaces. Most of the balance went to Luxemburg and the Saar district, both adjacent to the mining region. Westphalia obtained its ores chiefly from Spain and Sweden. With Westphalian coal in reparation payments and the Saar fields, France has the material resources beyond the requirements of a home market. Can the nation make use of these? Much will depend upon the workings of the new Continental Steel Entente; with the Germans holding the dominant position, the French industry may suffer.

France has other advantages over its industrial neighbors. It possesses potential hydroelectric power of almost 10 million horsepower, of which only one-third is used. New projects under construction will add 2 million, and will offset, in part, the shortage of labor. Chiefly an agricultural nation, with 73 per cent of the people on farms enjoying a higher standard of living than ever before, France depends less upon foreign foodstuffs than either Germany or the

[9] Following the Franco-Prussian War, 2 million spindles and 48,500 looms of Alsace went to Germany.

United Kingdom. The restored Alsatian potash and the development of the phosphate deposits of the North African colonies serve to keep up and to even increase the productiveness of French soil; a rather extensive introduction of modern machinery also increases the output and releases labor for the industries. In addition, France controls the second largest colonial empire, which embraces 4 million square miles and holds 50 million people, capable of supplying nearly all the raw materials for its expanding industries and of supplying a market for the mounting output of its factories. France stands upon the threshold of its industrial renaissance, with the opportunity to develop along many lines. Yet it seems that France will confine its attention more to its domestic and colonial markets than to active competition in the South American market with the standardized goods of a capitalistic production of the United States (Fig. 14).

COMMERCIAL STRENGTH

The United States, with the dominant position in South American trade, stands on the threshold of a far greater development. Now that it has become an industrial nation, an importer of raw materials and tropical foodstuffs, and an exporter of manufactured or semi-manufactured wares and prepared foodstuffs, it stands head and shoulders above European countries in competitive ability in the commerce of this southern continent. It has more people than the United Kingdom and Germany combined—only 6 per cent of the total of the world, but it uses one-half the basic materials of commerce. This population has a high standard of living and a productive capacity much greater than its competitors, and it increases at an amazing rate.

A few examples serve to indicate trends in this line and to affect the competitive

FIGURE 15.—Few remote mountain recesses are too isolated for men, money, machinery and supplies where rich mineral deposits await development. The tin ore of the Argentine mine, from which this picture was taken, moves over on aërial cable for 5½ miles, over a range of the Andes at 16,000 feet and down to the mill near Pongo at 12,000 feet. The whole development by the Guggenheim interests—the million dollar automobile road, the mill, the aërial cableway, and the Mines represent a remarkable achievement of man in combating the disadvantages of nature for the purpose of extracting minerals.

position abroad. Numerous makes of automobiles are being turned out with one-fourth the labor required in 1920. Ten years ago it took an hour and forty minutes of a workman's time to produce a pair of shoes; today it takes only 54 minutes. Ten years ago weavers operated 4 to 6 looms, now they manage 36; a few years ago textile mills wound warp beams with 50 pounds of cotton or wool, today 600 to 1,000 pounds are used. The productive ratio in the cotton industry per labor unit in the United Kingdom and the United States is 1 to 3.3 in favor of the latter. The United States mines 520 million tons of coal with 800,000 men, while the United Kingdom produces less than 300 million with 1,200,000 men. In the United Kingdom 20,000 miles of railway are operated by 700,000 workers; in the United States fourteen times the mileage—275,000—requires only two and one-half times that number of workers. In 1925 the average production per man, engaged in 22 basic industries in the United States, was 34 per cent greater than in 1920. While the population of the United States during the past dozen years has increased 17 per cent, the productivity of the nation has increased 30 to 35 per cent. Furthermore, in all lines vast savings have been accomplished, and goods have been standardized. All these trends mean a large output at lower prices, conditions which increase materially the competitive ability of the United States in foreign markets.

All these trends bolstered up by the greatest masses of capital the world has ever known—the national income per year amounts to almost 100 billion dollars—by the largest single block of fertile agricultural land on the globe, by a vast expanding market unequalled anywhere, and by a variety and a huge quantity of mineral resources place the United States in a dominating position. The United States mines 40 per cent of the world's coal, pumps 70 per cent of the petroleum, harnesses almost one-third of the world's developed water power, pours 52 per cent of the pig-iron, produces 55 per cent of the steel, smelts one-half of the copper, grows two-thirds of the cotton and the corn, harvests one-fifth of the wheat, cuts 52 per cent of the timber, consumes one-third of the raw cotton and more than one-fifth of the wool, makes 41 per cent of the shoes, and assembles 92 per cent of the automobiles. This productivity sustains the great purchasing power for rubber, silk, coffee, sugar, wool, minerals, hides, and a host of other commodities.

The chief competitors of the United States find massed in the grasp of a compactly united people, resources, wealth, and productive power greater than the world has known—greater than in the leading three trade rivals together. The products of this combined agricultural, commercial, and industrial complex move out along the trade channels of vast empires and small countries. They penetrate alike the darkest and deepest sections of the Amazonian forest and the remotest mining camp perched high among the eternal snows of the isolated Andean recesses (Fig. 15).

At the same time, South America, a continent of vast vacant spaces, partly undeveloped resources, and a varied population ready to move forward and upward in the scale of civilization, feels the pulse of progress. With the aid of American men, capital, and the interchange of goods to the advantage of both continents, it will experience an era of tremendous advancement.

A NATION'S WATER POWER*

Herman Stabler

Chief Conservation Branch, United States Geological Survey

MAN has ever sought to accomplish his purposes with a minimum of personal physical effort. This attribute has had a material, perhaps a controlling, influence on the progress of civilization. The strong primitive man impressed the energy of his fellows to serve his needs. Then animals were domesticated and taught to labor that mankind might be at ease. The winds and falling water were eventually harnessed in an attempt to satisfy an insatiable craving to accomplish more work with less effort. Then came the age of steam, or better the age of fuel energy, in which, at first through the medium of steam and later by direct oxidation in internal combustion machines, the energy of fuels was transmuted into mechanical energy as the preface to a great industrial era. As on the sea fuel power displaced the wind, so on the land it displaced the horse as a prime motive force in transportation, and has since remained the dominant factor in commerce.

Fuels and falling water stand out as the two great sources of energy now available for the stupendous industrial activities of contemporary civilization. These two have long been competitors but may now better be considered as partners, each supplementing the other and together providing mankind with an abundant and flexible source of energy. In early colonial days it was the custom to locate industries on streams, the power market being built around available sources of water power. But power is but one element in the cost of factory products. Once a transportable source of energy such as coal was developed, accessibility of raw materials, availability of labor, locus of market demand, and other major elements of cost began to dominate the location of industries and water powers were commonly passed over unless they happened to fit in with plans based primarily on other considerations. Sources of fuel power in the United States are enormous and reasonably well distributed. Toward the end of the eighteenth century they were fast driving water power into the background. Then followed discoveries and developments in electricity culminating in the manufacture of alternating current machinery and the practicable long-distance transmission of electric energy. It thus became unnecessary to transport fuel to the power market for electric energy could be generated from falling water or fuels and transmitted by wire for a few hundred miles at reasonable cost. A value thus arose for the relatively inaccessible water powers that bids fair to be augmented until all water powers are developed to the utmost limit. Furthermore, electric transmission initiated a trend from the small inefficient isolated power station to large central electric stations and systems with large power units and high diversity and load factors. Mechanical improvements, such as the steam turbine and the superheater, making for better use of fuels, inevitably followed this trend and accentuated it, preventing a more rapid development of water powers that would otherwise have taken place. We have now a most healthy condition in the power industry—water and fuels competing for supremacy in cheapness of development yet supplementing each other to give the most perfect and cheapest service when combined in extensive systems. Where water powers are abundant and can be economically developed, fuel as a source

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Figure 1.—Granite Wall Dam Site, Grand Canyon, Colorado. The high walls and narrow gap constitute a most favorable location for a dam of this kind. (Courtesy of U. S. Geol. Survey.)

of power is held as a reserve, supplying peak loads and supplementing steam shortage in low-water season. In other areas, where fuels are abundant, fuel power dominates the field, water powers, if developed at all, being used as feeders to the power stream but not being relied upon for base load. Fuels being an exhaustible resource, while water power is continuing, every effort should be made to supplant the former by the latter as a measure of conservation. Nevertheless, it must be recognized that the water powers of the nation are insufficient to supply our mounting needs for energy, that fuel supplies are practically unlimited as viewed in the light of use for a few hundred years, and that never again unless and until fuels reach a stage of appreciable exhaustion will falling water be the dominant source of energy supply for the United States.

Water Power Resources of the United States

What are the water power resources

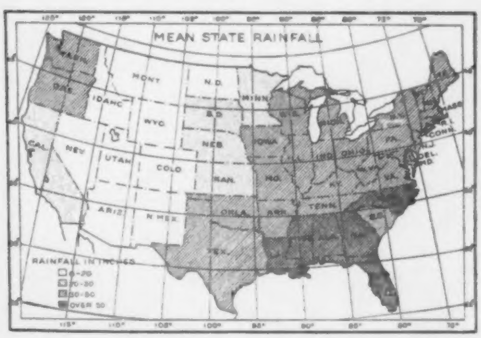

Figure 2.—The primary source of the nation's water supply is the adequate mean rainfall, which ranges from 100 inches a year along the northwestern and southeastern coasts and averages nearly 30 inches for the country as a whole.

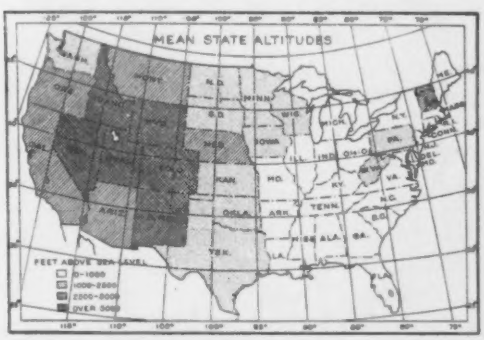

Figure 3.—As water itself will not generate power, the mean State altitudes map is an index to a second primary source of water power. Note the concentration of mean State altitudes in the Rocky Mountain section.

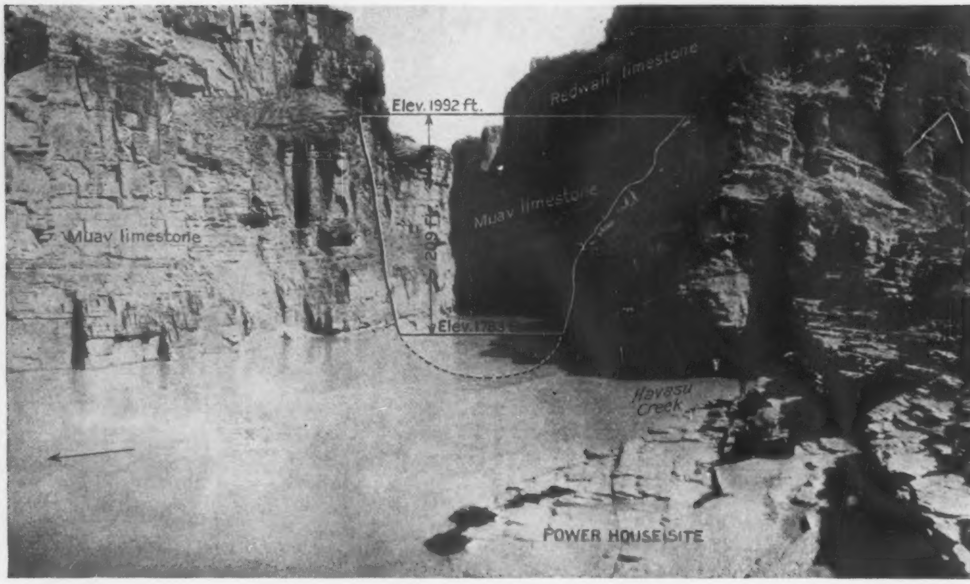

FIGURE 4.—Havasu Dam Site, Colorado River, below Grand Canyon National Park. The horsepower available 90 per cent of the time is 116,000, while 50 per cent of the time it is 179,000. With storage at Glen Canyon 363,000 continuous horsepower will be available. (Courtesy of U. S. Geol. Survey.)

of the United States? How derived? Where located? Evaporation from ocean surfaces, transportation of vapor inland, precipitation on the heights as rain or snow, and run-off in rills, rivulets, and rivers to the sea—that cycle so essential to the existence of mankind is likewise the source of his water powers. It is a cycle replete with wasted energy but prodigal nature with limitless resources and infinite time at command has small need of efficiency measured in man-made terms.

Mean state rainfall in the United States (Figure 2) ranges from a trace in the most desert regions to more than 100 inches a year along the northwestern and southeastern coasts and averages nearly 30 inches for the country as a whole. This is the primary source of the nation's water supply. But water of itself will not generate power. It is to water falling from an altitude that one must look for an energy supply. The map of mean state altitudes (Figure 3) is therefore an index to a second primary source of water powers. These two factors, rainfall and altitude, limit the resources. If all rain could be used to develop the power represented by its quantity and the altitude above sea level of the land on which it falls, the United States would have a limit of potential water power (Figure 5) of about one and a third billion horsepower, or more than 400 horsepower per square mile, truly a magnificent resource. But two-thirds of the precipitation consumed in maintaining vegetable and animal life or in evapora-

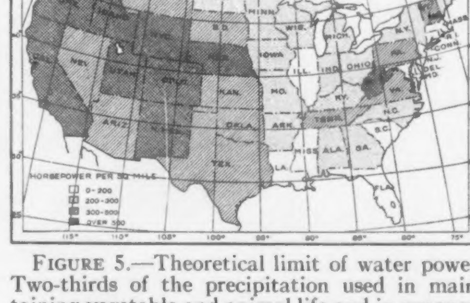

FIGURE 5.—Theoretical limit of water power. Two-thirds of the precipitation used in maintaining vegetable and animal life and in evaporation from plant, water, and land surfaces is lost underground, or fails to reach the sea through surface streams. The run-off solely, the remaining third, can be used for power.

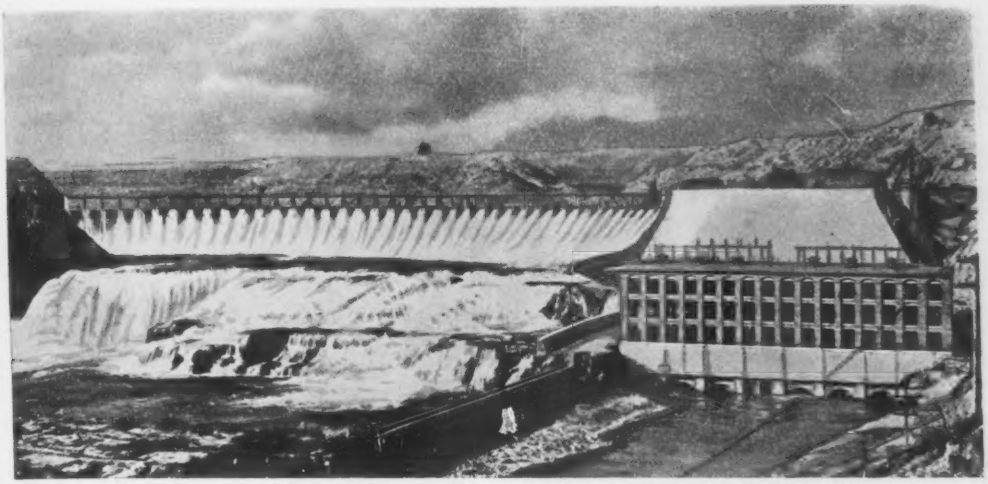

FIGURE 6.—Volta power plant of Montana Power Company at Great Falls on the Missouri River. The head is 150 feet, and the installed capacity is 91,500 horsepower. (Courtesy of U. S. Geol. Survey.)

tion from plant, water, and land surfaces, is lost underground, or otherwise fails to reach the sea through surface streams. The remaining third, the run-off, alone can be used for power. The areal distribution of rainfall and run-off, as shown by Figures 7 and 9, is markedly similar, the run-off, of course, being much the less. Considering run-off alone, instead of rainfall, the maximum limit of the national power resource is reduced to less than half a billion horsepower. Moreover, rainfall is notably irregular and the flow of streams erratic. Much water is therefore lost to useful purpose in destructive flood flows impracticable of storage and unsuited to economic development. Perhaps a third of the flow of streams is thus unavoidably lost and the total resource reduced to 300 million horsepower. Altitude can be fully utilized no more than rainfall. The appreciable part of the altitude of newly fallen rain is lost before it gathers in streams of sufficient size to be valuable for power purposes. Furthermore, concentrations of fall, natural or such as can be created by the building of dams or conduits, are essential to practicable development of water power. The streams of the United States carry to the sea some 800 million tons of mineral matter every year and wear down the land surface an inch in less than a thousand years. In this process of erosion natural concentrations of fall are disappearing and even now are practically unknown on heavily silt-laden streams. The habit of rivers to flatten their slopes reduces the opportunity to develop artificial concentrations of fall by building dams or conduits. Magnificent streams flow for many miles on slopes so flat that no known scheme of power development is practicable, their potential power being required to move the water sea-

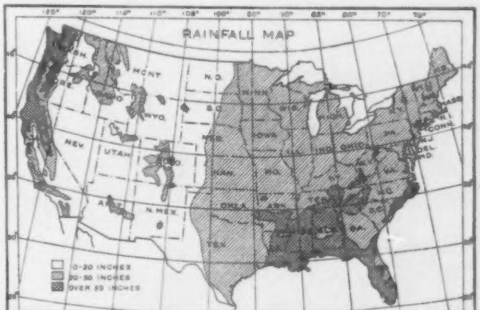

FIGURE 7.—In this rainfall map, note that the greatest concentration of rain is found in the states bordering the Gulf of Mexico and the Mississippi River. A notable portion of the altitude of newly fallen rain is lost before it collects in streams of sufficient size to be used for development of power.

FIGURE 8.—Mitchell Dam on Coosa River, Alabama, owned by Alabama Power Company. The head is 70 feet, and the installed capacity, 72,000 horsepower. (Courtesy of Fed. Power Comm.)

ward or being lost in the inevitable frictional losses of bed and banks and cross currents. Such, for example, is the Mississippi from Cairo to the Gulf. Allowing for these losses in altitude and for imperfect mechanical efficiency in the process of converting the energy of falling water into electricity it must be concluded that the utmost limit of usable water power in the United States does not exceed a hundred million horsepower.

Until all power sites have been surveyed, perhaps even until they have been developed, there will be uncertainty as to the assured extent of the water-power resources of the United States. The following table (Table I), prepared by the Geological Survey, is the best available estimate of such resources at the present time. That organization has for years been pursuing a definite program of investigation of water resources and evaluation of their extent and utility. The table is based in part on detailed information and in part on generalized estimates and incomplete data. It indicates that the conclusion as to the utmost limit of usable power is optimistic. A conclusion so derived is of value, however, in pointing out that there is an inescapable limit of power resources not so very far beyond the more reliable estimates based on detailed but admittedly incomplete information.

Under prevailing practice it is customary to install power machinery with capacity about 30 per cent in excess of the water-power resources available 50 per cent of the time. One may therefore look forward with some confidence to a time when water wheels with 80 million horsepower capacity will be in use.

DISTRIBUTION OF SOURCES OF WATER POWER

The mean state rainfall map of the United States (Figure 2) would lead one to expect a predominance of water-power resources in the eastern half of the country with greatest concentration in the southeast and least in the Rocky Mountain region. In marked contrast, the map of mean state altitudes (Figure 3) indicates a predominance of water power in the western half of the country with greatest concentration in the Rocky Mountain region and least in the southeast. A composite picture of the two primary sources of water power, rainfall and altitude, is given by the map of theoretical limit of water power (Figure 5). Here three regions of water-power resources are recognizable. First, the Rocky Mountain region, easily predomi-

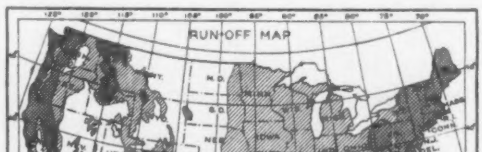

FIGURE 9.—Note that the areal distribution of rainfall and run-off (Figures 7 and 9) are similarly marked, although run-off is much the less. The greatest amount of run-off is found along the Atlantic and Pacific coasts, although there is also a great deal in the states bordering the Mississippi and its tributaries.

TABLE I

POTENTIAL WATER-POWER RESOURCES OF THE UNITED STATES

State and Division	*Available 90 per Cent of the Time*		*Available 50 per Cent of the Time*	
	Horsepower	Per Cent	Horsepower	Per Cent
United States	34,818,000	100.00	55,030,000	100.00
New England	998,000	2.87	1,978,000	3.60
Middle Atlantic	4,317,000	12.40	5,688,000	10.35
East North Central	737,000	2.12	1,391,000	2.53
West North Central	871,000	2.50	1,844,000	3.35
South Atlantic	2,476,000	7.11	4,464,000	8.11
East South Central	1,011,000	2.90	2,004,000	3.64
West South Central	434,000	1.25	888,000	1.61
Mountain	10,736,000	30.83	15,513,000	28.19
Pacific	13,238,000	38.02	21,260,000	38.63
New England:				
Maine	536,000	1.54	1,074,000	1.95
New Hampshire	186,000	.53	350,000	.64
Vermont	80,000	.23	169,000	.31
Massachusetts	106,000	.31	235,000	.43
Rhode Island	25,000	.07	40,000	.07
Connecticut	65,000	.19	110,000	.20
Middle Atlantic:				
New York	4,010,000	11.52	4,960,000	9.03
New Jersey	50,000	.14	90,000	.16
Pennsylvania	257,000	.74	638,000	1.16
East North Central:				
Ohio	55,000	.16	166,000	.30
Indiana	40,000	.12	110,000	.20
Illinois	189,000	.54	361,000	.66
Michigan	168,000	.48	274,000	.50
Wisconsin	285,000	.82	480,000	.87
West North Central:				
Minnesota	203,000	.58	401,000	.73
Iowa	169,000	.49	395,000	.72
Missouri	67,000	.19	152,000	.27
North Dakota	82,000	.23	193,000	.35
South Dakota	63,000	.18	110,000	.20
Nebraska	183,000	.53	342,000	.62
Kansas	104,000	.30	251,000	.46
South Atlantic:				
Delaware	5,000	.01	10,000	.02
Maryland and District of Columbia	106,000	.30	238,000	.43
Virginia	459,000	1.32	812,000	1.48
West Virginia	355,000	1.02	980,000	1.78
North Carolina	540,000	1.55	816,000	1.48
South Carolina	429,000	1.23	632,000	1.15
Georgia	572,000	1.65	958,000	1.74
Florida	10,000	.03	18,000	.03
East South Central:				
Kentucky	77,000	.22	184,000	.33
Tennessee	432,000	1.24	710,000	1.29
Alabama	472,000	1.35	1,050,000	1.91
Mississippi	30,000	.09	60,000	.11
West South Central:				
Arkansas	125,000	.36	178,000	.32
Louisiana	1,000	.00	2,000	.00
Oklahoma	70,000	.20	194,000	.35
Texas	238,000	.69	514,000	.94
Mountain:				
Montana	2,550,000	7.32	3,700,000	6.72
Idaho	2,122,000	6.10	4,032,000	7.33
Wyoming	704,000	2.02	1,182,000	2.15
Colorado	765,000	2.20	1,570,000	2.85
New Mexico	116,000	.33	186,000	.34
Arizona	2,759,000	7.92	2,887,000	5.25
Utah	1,420,000	4.08	1,586,000	2.88
Nevada	300,000	.86	370,000	.67
Pacific:				
Washington	4,970,000	14.27	7,871,000	14.30
Oregon	3,665,000	10.53	6,715,000	12.20
California	4,603,000	13.22	6,674,000	12.13

nant; second, the Pacific Coast region; and third, the Appalachian province. This picture is misleading as a guide to distribution of water powers mainly because of the erroneous assumption in its composition that altitude is an evidence of water power in place whereas the development of the power indicated must

FIGURE 10.—Twin Falls, Snake River, Idaho, undeveloped. There is a fall of 140 feet and also a 75-foot dam, with a gross head of 205 feet. The 90 per cent time power is 9,000, while the 50 per cent time power is 92,000. Following complete utilization, there is 12,000 horsepower for 90 and 50 per cent time power. (Courtesy of U. S. Geol. Survey.)

be distributed along the path the water takes in flowing from the mountains to the sea and a great measure of the potential power will be dissipated as the water flows. A thousand feet of altitude at the sea coast is practically as effective as 4,000 feet a thousand miles inland. Thus the predominance of the Rocky Mountain region is overcome by the lower but more usable mean altitudes near the Pacific Coast and the potential power of the central portion of the United States is practically lost to useful purpose. A fairly accurate representation of the potential water-power resources of the United States and its areal distribution is found in the map of water-power resources available 50 per cent of the time (Figure 11) which has been compiled by the U. S. Geological Survey from all available information including a very large number of detailed stream studies. This map shows the Pacific Coast area predominant, three states with 11 per cent of the area of the country containing 39 per cent of its water-power resources; six Rocky Mountain States with 21 per cent of the area containing 27 per cent of the water power; and fifteen Appalachian-Atlantic Coast states with 13 per cent of the area containing 22 per cent of the water power. These three regions have a scant 45 per cent of the area of the United States but within their limits are 88 per cent of its water powers.

A slightly different picture of distribution of water powers is offered by the map showing water-power resources available 90 per cent of the time (Figure 12). This map, based on data compiled by the U. S. Geological Survey, shows the water power estimated to be available at the ordinarily low stage of streams, supplemented in certain areas, however, by the effect of known storage reservoir sites. On the whole the regional concentrations of power indicated by the two maps are very similar.

The influence of physiography on

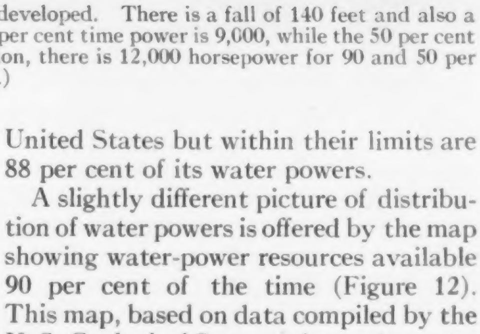

FIGURE 11.—This map of water-power resources available 50 per cent of the time, compiled by the U. S. Geological Survey, gives a fairly accurate representation of the potential water power resources of the United States and its areal distribution.

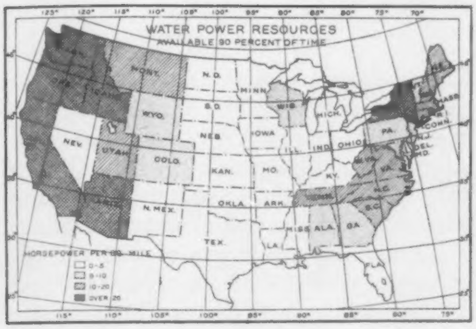

FIGURE 12.—This map, compiled by the U. S. Geological Survey, shows the water power estimated to be available at the ordinarily low stage streams, supplemented on certain areas by the effect of known storage reservoir sites.

distribution of water powers is suggested by comparison of the maps of water-power resources (Figures 11 and 12) with the map showing physiographic provinces of the United States (Figure 14). States high in water power per unit of area are characterized by transition zones from one physiographic province to another, such zones being areas in which concentrations of fall are likely to exist. Thus, of the states having over 20 horse-power per square mile available 90 per cent of the time California has concentrations of power resulting from rapid transition from the Pacific Mountain System to sea level; Oregon and Washington resulting from transition from the Rocky Mountain System to the Intermontane Plateau, and from this plateau and the Pacific Mountain System to the sea; Arizona, resulting from transition from the Intermontane Plateau to sea level; Idaho, resulting from transition from the Rocky Mountain System to the lower part of the Intermontane Plateau; and New York resulting from transition from the Interior Plains and Appalachian Highlands to near sea level in the Laurentian lowlands. New York affords at Niagara the finest example in the United States of that ideal condition for water power—a great upland gathering ground for waters which, when accumulated, fall rapidly to the sea. The Columbia and Colorado River basins likewise provide great upland gathering grounds for water but the fall thereafter to sea level, though greater than at Niagara, is less abrupt. The Columbia, Colorado, and St. Lawrence River systems provide the

FIGURE 13.—Great Falls on Potomac River, near Washington, D. C. The horsepower available 90 per cent of the time is 10,500, while that available 50 per cent of the time is 35,000. The average minimum horsepower with storage at site is 19,000. (Courtesy of U. S. Geol. Survey.)

FIGURE 14.—By comparing the maps of water-power resources with the map showing physiographic provinces of the United States, one may plainly see the influence of physiography on distribution of water powers. States that have high water power per unit of area are shown by transition zones from one physiographic province to another, such zones being areas in which concentrations of fall are likely to exist.

three really great concentrations of water power in the United States. The transition from the Interior Plains to the Atlantic Plain in the basin of the Mississippi is so gradual that this river basin may be regarded as in a single plains province of gradual slope, fringed only to northwest and northeast by highland provinces and slightly broken by the area of interior highlands. This great stream basin, comprising upwards of half the area of the United States, is not productive of many notable water powers.

DEVELOPMENT OF WATER-POWER RESOURCES

The extent to which the water-power resources of the United States have been developed is indicated by the map showing water-wheel capacity in 1927 (Figure 16). In general this presents the same picture of distribution of water powers as is afforded by the maps of water-power resources available 50 per cent and 90 per cent of the time (Figures 11 and 12)—that is, the eastern and western portions of the country are shown to contain substantially all of the developed as well as the potential water power. There is this notable difference however. The west outweighs the east in resources, but the east has outstripped the west, naturally enough, in development. In no state west of Mississippi River has installed water-wheel capacity per square mile equalled the water resources per square mile available 90 per cent of the time. In New England, the Carolinas, and certain north-central States alone has this degree of development been reached. The notable industrial, thickly populated, or early settled states have naturally gone farthest toward complete development, but in all parts of the country there is opportunity for much further development.

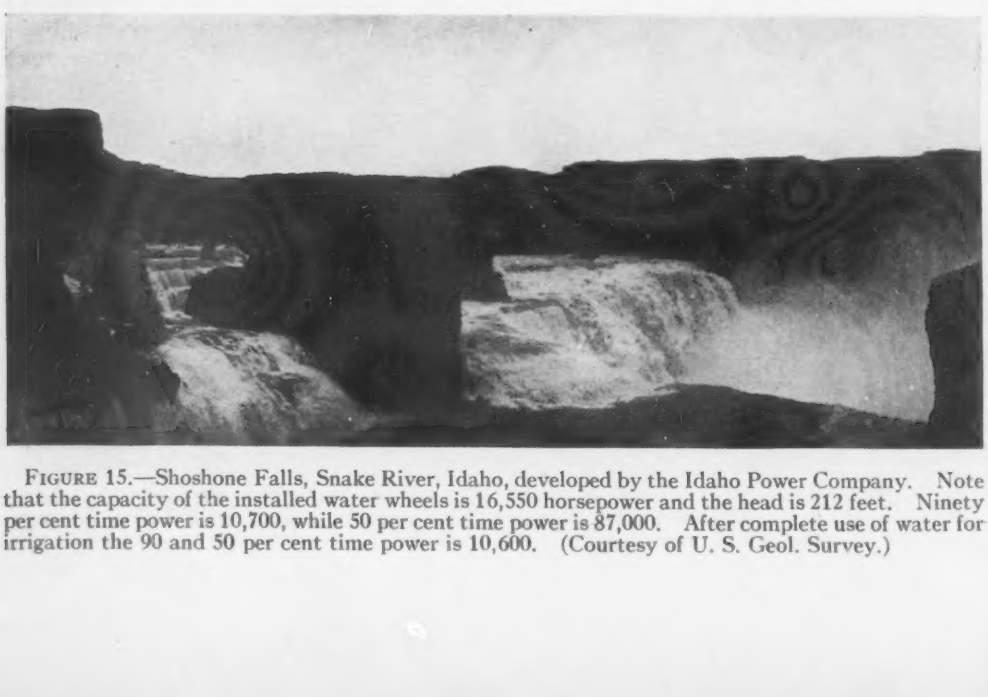

FIGURE 15.—Shoshone Falls, Snake River, Idaho, developed by the Idaho Power Company. Note that the capacity of the installed water wheels is 16,550 horsepower and the head is 212 feet. Ninety per cent time power is 10,700, while 50 per cent time power is 87,000. After complete use of water for irrigation the 90 and 50 per cent time power is 10,600. (Courtesy of U. S. Geol. Survey.)

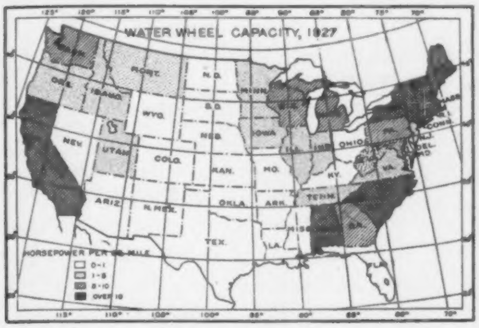

FIGURE 16.—The extent to which water-power resources of the United States have been developed is indicated by the above map, showing the water-wheel capacity in 1927. By comparing this map with Figures 11 and 12 it is seen that while the resources of the West are greater, the East has outstripped the West in development.

The following table, prepared by the U. S. Geological Survey, shows the distribution of the developed water power in the United States from 1908 to 1927. The percentages for 1908 are based on the total capacity of water wheels in plants of all sizes. The percentages for 1921 to 1927 are based on the capacity of water wheels in plants of 100 horsepower or more. The general westward trend of power development and the recent development in the southeast are clearly indicated.

TABLE II

DISTRIBUTION OF THE DEVELOPED WATER POWER IN THE UNITED STATES FOR DIFFERENT YEARS

Division	*Percentage of Total in United States*					
	1908*	1921	1924	1925	1926	1927
New England	20.8	16.5	15.3	14.0	13.3	13.1
Middle Atlantic	22.8	18.7	19.1	19.4	17.9	17.5
East North Central	10.1	9.3	9.1	8.8	8.8	8.6
West North Central	4.2	5.6	5.1	5.1	4.7	4.6
South Atlantic	13.0	13.6	14.3	15.8	15.2	15.7
East South Central	5.2	3.1	3.8	4.0	6.7	7.4
West South Central	.4	.2	.2	.3	.3	.3
Mountain	7.7	10.4	9.7	9.3	8.8	8.8
Pacific	15.8	22.6	23.5	23.3	24.5	24.0

* Plants of all sizes; other years, plants of 100 horsepower or more.

Table III, also from data compiled by the U. S. Geological Survey, shows the number and capacity of water-power plants in the United States in 1927. Apparently about a seventh of the eventual installation has been accomplished.

UTILIZATION OF WATER POWERS

The installed water-wheei capacity presents a too optimistic picture of the progress of water-power utilization. The map of water power generated by public utility plants (Figure 18) affords a better criterion of use. More than 80 per cent of the water power generated in the United States is in public utility plants. In a few states lumber, paper, and textile industries developed a material part of the water powers prior to the advent of electric energy in the public utility field. With these exceptions, the public utility field is today the field for water-power utilization. Continuous use of between 30 and 40 per cent of installed water-wheel capacity is all that is suggested by the statistics of output of energy.

The following tables, Table IV and V, prepared by the U. S. Geological Survey, show the statistics of water power used in the public utility field and its relation to fuel power.

FIGURE 17.—This Big Creek Power House, No. 3, on the San Joaquin River, owned by the California Edison Power Company, is shown during construction. The static head is 830 feet, while the installed capacity is 105,000 horsepower. (Courtesy of Fed. Power Comm.)

TABLE III

DEVELOPED WATER POWER IN THE UNITED STATES JANUARY 1, 1927
(Plants of 100 Horsepower or More)

Division and State	*Total*		*Public Utility and Municipal*		*Manufacturing and Miscellaneous*	
	Number of Plants	Capacity in Horsepower	Number of Plants	Capacity in Horsepower	Number of Plants	Capacity in Horsepower
United States	3,390	11,720,983	1,565	9,961,202	1,825	1,759,781
New England	1,221	1,535,468	264	779,449	957	756,019
Middle Atlantic	613	2,055,853	239	1,757,413	374	298,440
East North Central	369	1,009,915	250	770,424	119	239,491
West North Central	201	532,894	150	436,450	51	96,444
South Atlantic	341	1,841,197	161	1,600,339	180	240,858
East South Central	60	867,638	45	863,681	15	3,957
West South Central	29	32,333	18	28,828	11	3,505
Mountain	245	1,030,224	196	1,010,743	49	19,481
Pacific	311	2,815,461	242	2,713,875	69	101,586
New England:						
Maine	250	525,509	78	222,570	172	302,939
New Hampshire	244	277,252	62	143,711	182	133,541
Vermont	196	200,157	66	156,501	130	43,656
Massachusetts	348	353,939	33	171,977	315	181,962
Rhode Island	59	30,188	5	3,285	54	26,903
Connecticut	124	148,423	20	81,405	104	67,018
Middle Atlantic:						
New York	529	1,757,355	186	1,474,100	343	283,255
New Jersey	34	18,902	10	8,658	24	10,244
Pennsylvania	50	279,596	43	274,655	7	4,941
East North Central:						
Ohio	24	30,320	16	25,236	8	5,084
Indiana	24	56,156	16	52,341	8	3,815
Illinois	31	94,202	16	77,277	15	16,925
Michigan	128	355,261	108	307,080	20	48,181
Wisconsin	162	473,976	94	308,490	68	165,486
West North Central:						
Minnesota	69	274,589	47	196,271	22	78,318
Iowa	49	179,580	40	177,980	9	1,600
Missouri	7	20,560	5	20,260	2	300
North Dakota	1	245	0	0	1	245
South Dakota	9	19,671	5	7,050	4	12,621
Nebraska	43	21,335	38	20,532	5	803
Kansas	23	16,914	15	14,357	8	2,557
South Atlantic:						
Delaware	3	1,161	0	0	3	1,161
Maryland	15	37,875	4	33,825	11	4,050
District of Columbia	2	1,350	0	0	2	1,350
Virginia	62	138,046	32	96,432	30	41,614
West Virginia	12	91,279	7	81,174	5	10,105
North Carolina	122	542,618	47	410,556	75	132,062
South Carolina	59	571,428	32	543,321	27	28,107
Georgia	62	448,670	36	426,381	26	22,289
Florida	4	8,770	3	8,650	1	120
East South Central:						
Kentucky	6	34,255	3	33,351	3	904
Tennessee	31	174,175	24	172,920	7	1,255
Alabama	23	659,208	18	657,410	5	1,798
Mississippi	0	0	0	0	0	0
West South Central:						
Arkansas	4	15,550	4	15,550	0	0
Louisiana	0	0	0	0	0	0
Oklahoma	4	1,948	4	1,948	0	0
Texas	21	14,835	10	11,330	11	3,505
Mountain:						
Montana	31	376,040	29	374,100	2	1,940
Idaho	52	320,097	45	317,095	7	3,002
Wyoming	10	10,480	9	10,154	1	326
Colorado	60	95,554	32	84,401	28	11,153
New Mexico	7	1,808	7	1,808	0	0
Arizona	9	59,360	9	59,360	0	0
Utah	67	153,435	57	150,675	10	2,760
Nevada	9	13,450	8	13,150	1	300
Pacific:						
Washington	75	656,722	68	630,590	7	26,132
Oregon	82	241,759	47	185,387	35	56,372
California	154	1,916,980	127	1,897,898	27	19,082

TABLE IV

PRODUCTION OF ELECTRIC POWER BY PUBLIC-UTILITY POWER PLANTS * IN THE UNITED STATES IN 1926

Division and State	*Total Power* Kilowatt Hours	*Total Power* Per Cent of U. S. Total	*Water Power* Kilowatt Hours	*Water Power* Per Cent of Total Power	*Water Power* Per Cent of U. S. Water Power	*Fuel Power* Kilowatt Hours	*Fuel Power* Per Cent of Total Power	*Fuel Power* Per Cent of U. S. Fuel Power
United States	73,791,064,000	100.00	26,188,801,000	35.5	100.00	47,602,263,000	64.5	100.00
New England	5,165,955,000	7.00	1,684,790,000	32.6	6.43	3,481,165,000	67.4	7.31
Middle Atlantic	20,526,802,000	27.82	6,049,534,000	29.5	23.10	14,477,268,000	70.5	30.41
East North Central	17,663,578,000	23.94	2,068,978,000	11.7	7.90	15,594,600,000	88.3	32.76
West North Central	4,586,814,000	6.22	1,515,433,000	33.0	5.78	3,071,381,000	67.0	6.45
South Atlantic	7,197,294,000	9.75	2,086,872,000	29.0	7.97	5,110,422,000	71.0	10.75
East South Central	3,049,199,000	4.13	1,925,679,000	63.2	7.35	1,123,520,000	36.8	2.36
West South Central	2,639,520,000	3.58	48,876,000	1.9	.19	2,590,644,000	98.1	5.44
Mountain	3,424,715,000	4.64	2,833,527,000	82.7	10.83	591,188,000	17.3	1.24
Pacific	9,537,187,000	12.92	7,975,112,000	83.6	30.45	1,562,075,000	16.4	3.28
New England:								
Maine	544,423,000	.74	515,102,000	94.6	1.97	29,321,000	5.4	.06
New Hampshire	263,524,000	.36	214,855,000	81.5	.82	48,669,000	18.5	.10
Vermont	264,914,000	.36	259,493,000	98.0	.99	5,421,000	2.0	.01
Massachusetts	2,498,915,000	3.39	494,797,000	19.8	1.89	2,004,118,000	80.2	4.21
Rhode Island	476,239,000	.64	5,524,000	1.2	.02	470,715,000	98.8	.99
Connecticut	1,117,940,000	1.51	195,019,000	17.4	.74	922,921,000	82.6	1.94
Middle Atlantic:								
New York	11,332,507,000	15.36	5,178,776,000	45.7	19.78	6,153,731,000	54.3	12.93
New Jersey	1,736,881,000	2.35	2,715,000	.2	.01	1,734,166,000	99.8	3.64
Pennsylvania	7,457,414,000	10.11	868,043,000	11.6	3.31	6,589,371,000	88.4	13.84
East North Central:								
Ohio	4,761,028,000	6.45	46,682,000	1.0	.18	4,714,346,000	99.0	9.90
Indiana	1,758,435,000	2.38	140,927,000	8.0	.54	1,617,508,000	92.0	3.40
Illinois	5,930,399,000	8.04	223,132,000	3.8	.85	5,707,267,000	96.2	11.99
Michigan	3,392,813,000	4.60	787,328,000	23.2	3.01	2,605,485,000	76.8	5.47
Wisconsin	1,820,903,000	2.47	870,909,000	47.8	3.32	949,994,000	52.2	2.00
West North Central:								
Minnesota	1,040,191,000	1.41	587,198,000	56.5	2.24	452,993,000	43.5	0.95
Iowa	1,344,978,000	1.82	778,368,000	57.9	2.97	566,610,000	42.1	1.19
Missouri	912,503,000	1.24	74,365,000	8.1	.28	838,138,000	91.9	1.76
North Dakota	47,555,000	.06	0	.0	.00	47,555,000	100.0	.10
South Dakota	80,342,000	.11	8,319,000	10.3	.03	72,023,000	89.7	.15
Nebraska	394,832,000	.54	34,075,000	8.6	.13	360,757,000	91.4	.76
Kansas	766,413,000	1.04	33,108,000	4.3	.13	733,305,000	95.7	1.54
South Atlantic:								
Delaware	118,866,000	.16	0	.0	.00	118,866,000	100.0	.25
Maryland	587,989,000	.80	36,139,000	6.1	.14	551,850,000	93.9	1.16
District of Columbia	381,373,000	.52	0	.0	.00	381,373,000	100.0	.80
Virginia	925,882,000	1.26	206,283,000	22.3	.79	719,599,000	77.7	1.51
West Virginia	1,807,360,000	2.45	118,061,000	6.5	.45	1,689,299,000	93.5	3.55
North Carolina	1,117,378,000	1.51	412,670,000	36.9	1.58	704,708,000	63.1	1.48
South Carolina	1,038,198,000	1.41	681,952,000	65.7	2.60	356,246,000	34.3	.75
Georgia	710,578,000	.96	613,548,000	86.3	2.34	97,030,000	13.7	.20
Florida	509,670,000	.69	18,219,000	3.6	.07	491,451,000	96.4	1.03
East South Central:								
Kentucky	513,800,000	.70	64,357,000	12.5	.24	449,443,000	87.5	.94
Tennessee	894,015,000	1.21	557,229,000	62.3	2.13	336,786,000	37.7	.71
Alabama	1,582,717,000	2.14	1,304,093,000	82.4	4.98	278,624,000	17.6	.58
Mississippi	58,667,000	.08	0	.0	.00	58,667,000	100.0	.12
West South Central:								
Arkansas	163,697,000	.22	33,035,000	20.2	.13	130,662,000	79.8	.27
Louisiana	519,793,000	.70	0	.0	.00	519,793,000	100.0	1.09
Oklahoma	463,128,000	.63	5,638,000	1.2	.02	457,490,000	98.8	.96
Texas	1,492,902,000	2.02	10,203,000	.7	.04	1,482,699,000	99.3	3.11
Mountain:								
Montana	1,407,903,000	1.91	1,397,232,000	99.3	5.34	10,671,000	0.7	0.02
Idaho	810,789,000	1.10	808,522,000	99.7	3.09	2,267,000	.3	.00
Wyoming	59,381,000	.08	11,223,000	18.9	.04	48,158,000	81.1	.10
Colorado	561,962,000	.76	215,092,000	38.3	.82	346,870,000	61.7	.73
New Mexico	25,993,000	.04	1,021,000	3.9	.00	24,972,000	96.1	.05
Arizona	172,243,000	.23	129,884,000	75.4	.50	42,359,000	24.6	.09
Utah	349,604,000	.47	235,112,000	67.2	.90	114,492,000	32.8	.24
Nevada	36,840,000	.05	35,441,000	96.2	.14	1,399,000	3.8	.00
Pacific:								
Washington	1,807,792,000	2.45	1,744,356,000	96.5	6.66	63,436,000	3.5	.13
Oregon	831,135,000	1.13	584,555,000	70.3	2.23	246,580,000	29.7	.52
California	6,898,260,000	9.35	5,646,201,000	81.8	21.56	1,252,059,000	18.2	2.63

* Central stations and electric railway plants.

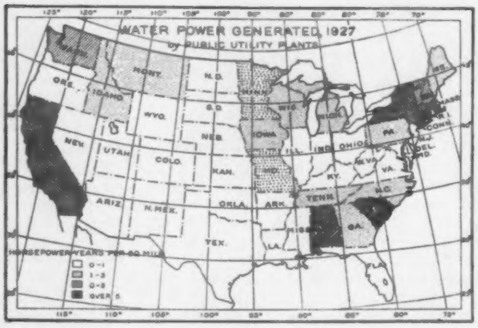

FIGURE 18.—Water power has played an important rôle in the progress of civilization. More than 80 per cent of the water power generated in the United States is in public utility plants.

out as major sources of water power in the United States.

Considerations of climate and topography indicate that the usable water-power resources of the United States cannot exceed 100 million horsepower. So far as known from incomplete engineering studies of river systems, the nation's water powers amount to about 50 million horsepower 50 per cent of the time and will justify eventual installation capable of generating about 80 million horsepower. About a seventh of this installation has been made, and the machinery installed is used at about one-third of its capacity.

TABLE V

ANNUAL PRODUCTION OF ELECTRICITY BY PUBLIC-UTILITY POWER PLANTS IN THE UNITED STATES, 1919–1926

Year	*Total* Kilowatt Hours	*Water Power* Kilowatt Hours	Per Cent of Total	*Fuel Power* Kilowatt Hours	Per Cent of Total
1919	38,921,000,000	14,606,000,000	37.5	24,315,000,000	62.5
1920	43,555,000,000	16,150,000,000	37.1	27,405,000,000	62.9
1921	40,976,000,000	14,971,000,000	36.5	26,005,000,000	63.5
1922	47,659,000,000	17,206,000,000	36.1	30,453,000,000	63.9
1923	55,674,000,000	19,348,000,000	34.8	36,327,000,000	65.2
1924	59,014,000,000	19,969,000,000	33.8	39,044,000,000	66.2
1925	65,870,000,000	22,356,000,000	33.9	43,514,000,000	66.1
1926	73,791,064,000	26,189,000,000	35.5	47,602,000,000	64.5

It is unlikely that water power will exceed more than about a third of the energy generated by public utilities.

SUMMARY

Water power has played an important rôle in the progress of civilization. It will continue to play an important though secondary rôle in the operation of public utilities.

Precipitation and altitude are the fundamental sources of water power. Even seasonal distribution of rainfall or storage basins to regulate run-off, large gathering grounds for surface water at high altitude, and concentration of changes in altitude, are conditions favorable to great water-power resources and their utilization. These factors have made the St. Lawrence, the Columbia, and the Colorado River systems stand

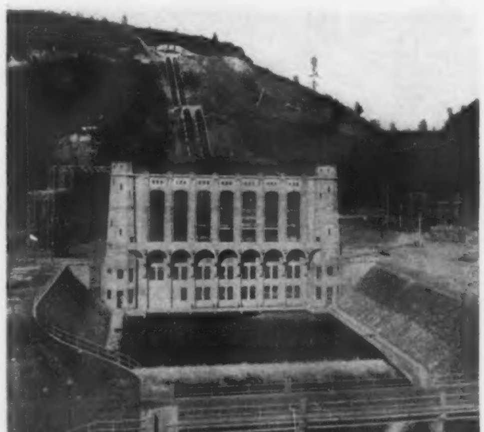

FIGURE 19.—This illustration of the Pacific Gas and Electric Company, Pitt Plant No. 1, shows plainly the rôle that water power plays in the field of public utilities. The head is 454 feet, while the installed capacity is 80,000 horsepower. (Courtesy of Fed. Power Comm.)

AGRICULTURAL REGIONS OF NORTH AMERICA

Part IV—The Corn Belt

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THIS region includes that portion of the east central United States in which corn (maize) is produced in great quantities and is more important than any other crop. It comprises western Ohio, central and northern Indiana and Illinois, Iowa, except the northeastern corner, the southwestern portion of Minnesota, southeastern South Dakota, eastern and southern Nebraska, the northern tier of counties of Kansas, except the westernmost county, and most of Missouri north of the Missouri River (Fig. 79).[1] The region is about 900 miles long by 150 to 300 miles wide, and contains an area of 150 million acres, or 8 per cent of the land area of the United States. In 1919 it produced on 90 million acres crops valued at three and a quarter billion dollars, which was nearly 25 per cent of the total for the nation.[2] The 850,000 farms in the Corn Belt, only 13 per cent of the total number in the United States, were valued in 1919 at 35 per cent of the value of all farms in the nation. In Iowa the average value was nearly $50,000 per farm.

In all counties of the region, except those along the semi-arid western margin, the average annual production of corn per square mile exceeds 1,000 bushels, and in a few counties reaches 10,000 bushels and more. The yearly average production along the southern margin is 3,000 bushels per square mile and this is generally true also along the northern and eastern margins (Fig. 109). On the average, the Corn Belt produces 5,000 bushels of corn per square mile, and, in addition, about 2,500 bushels of oats, over 1,000 bushels of wheat, 150 tons of hay and fodder, and provides also about 140 acres of pasture. The value of the crops per square mile, $15,000 in the year 1919, is over 60 per cent greater than in any other agricultural region.

The Corn Belt produces more feed for livestock and more meat for man than any other area of equal size in the world. It may not inappropriately be called the heart of American agriculture. The grain crop of the Corn Belt, over 60 per cent corn, exceeds 2,600 million bushels, which is nearly half that of the entire United States. Over half of the corn is fed to hogs (Fig. 110). Into the Corn Belt flow stocker and feeder cattle from the West for fattening, to supplement its home-grown stock, and out of it flow more than half of the beef and pork consumed in the eastern, northern, and to a lesser extent, in the southeastern sections of the country (Figs. 111 and 112). It supplies, moreover, most of the large exports of pork and lard; and, in addition, ships corn and hay in vast quantities to the eastern and southern markets (Fig. 113).

Although the Corn Belt includes only 8 per cent of the land area of the United States, it produced over 50 per cent of the nation's corn and oats crop in 1919, 25 per cent of the nation's wheat and hay, and possessed over 20 per cent of the cattle, 25 per cent of the horses, 28

[1] Economic Geography, July, 1927, issue, "Agricultural Regions of North America," Part III, by the author; or consult colored map of agricultural regions, frontispiece in October, 1926, issue.

[2] This article was written before the returns from the 1924 census were available for the region. These latest census returns will alter some of the figures given, particularly those of value, and make certain of the statements appear less appropriate. But the agricultural situation that has developed since the World War is abnormal, and the statements made in this article will likely be more applicable a decade hence than statements based on the 1925 census.

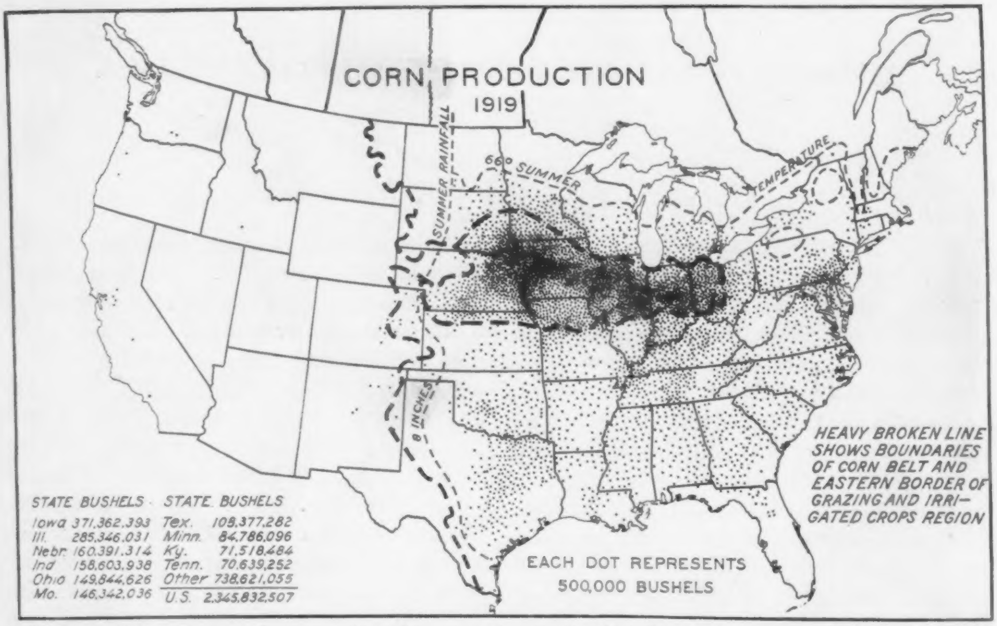


FIGURE 109.—Corn is the great American cereal, constituting about 60 per cent of the tonnage of all cereals grown in the United States, and over 50 per cent of the value. More than half of this crop is produced in the Corn Belt, but corn is the leading crop in value also in the Corn and Winter Wheat Belt, and is the all-important cereal in the Cotton Belt. Corn is a very productive crop, yielding, in general, about twice as many pounds of grain per acre as wheat, oats, barley, or rye. The climate and soil of the Corn Belt are peculiarly suited to it. Probably no other area in the world of equal extent produces so much feed per square mile as the Corn Belt. (U. S. Dept. of Agr. Yearbook, 1921.)

per cent of the poultry, and 43 per cent of the hogs of the nation. It contained, on January 1, 1920, about 21,500,000 animal units,[3] as compared with 12,263,000 human population. This is 94 animal units per square mile, which is equivalent to a horse or steer for every 6.8 acres. There were on the average 23 animal units per farm, January 1, 1919, which is more than twice as many as in the Corn and Winter Wheat Belt and three times as many as in the Cotton Belt.

About 84 per cent of the crop land in 1919 produced feed for farm animals and 16 per cent food consumed directly by man, wheat being the most important food crop (Fig. 114). Only one-fifth of 1 per cent of the crop acreage was used for other than feed and food crops. The corn crop of the Corn Belt, about double in size the wheat crop of the entire United States, affords a vast reserve of food in time of need. If used directly for human consumption it would provide fifteen bushels for every person in the United States at present, which is about thrice the present per capita consumption of wheat. Were the American people content to live on grain, supplemented by green vegetables and a little pork, with poultry and eggs now and then, as the people of China are compelled to live, the corn crop of the Corn Belt would be almost sufficient to feed the present population of the United States.

[3] An animal unit is a mature horse, cow or steer, 5 hogs, 7 sheep, or 100 poultry. Colts and calves are counted as half a unit, young pigs as one-tenth, and lambs as one-fourteenth.

THE PHYSICAL CONDITIONS

Although the Corn Belt occupies less than one-half of 1 per cent of the land surface of the earth and although only about one-fourth of the total land area of the Corn Belt is in corn, the region produces one-third of the corn crop of the world, and nearly two-thirds of the

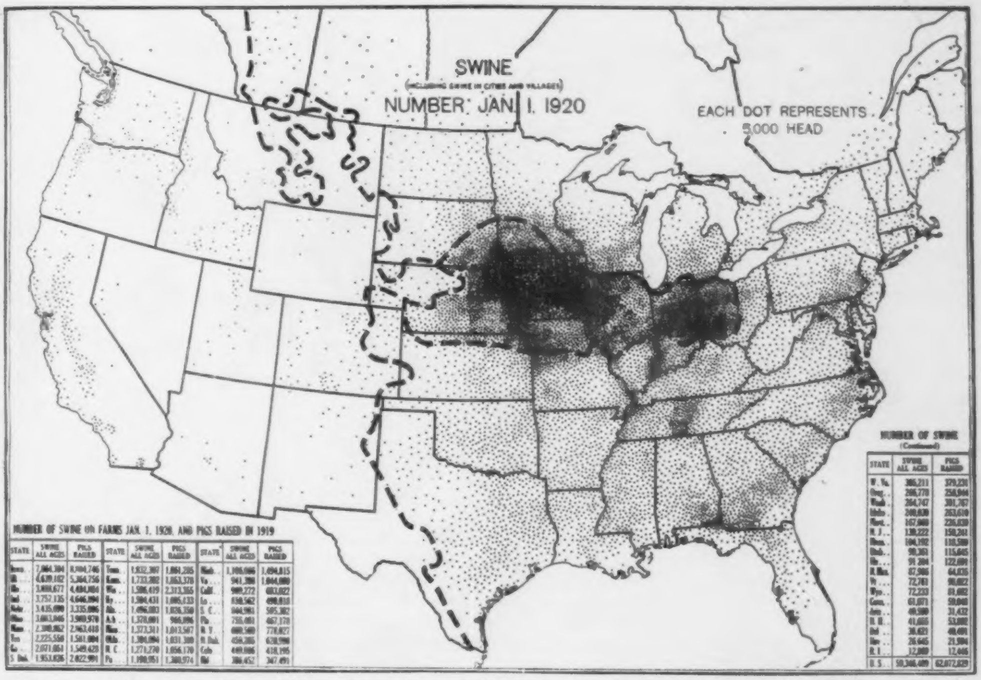


FIGURE 110.—About two-fifths of the hogs and pigs in the United States and Canada are in the Corn Belt, which is shown in outline on the map, nearly one-fifth are in the Cotton Belt, and nearly another fifth in the Corn and Winter Wheat Region. In 1919 there were, on the average, 106 swine per square mile in the Corn Belt, 33 in the Corn and Winter Wheat Region, 27 in the Cotton Belt, 17 in the Hay and Dairying Region, and about 4 per square mile in the remainder of the United States. Just as the cool Hay and Dairying Region finds the best outlet for its crops in feeding dairy cows, so the warm, rich Corn Belt finds the growing of corn and feeding of beef cattle and hogs its most profitable system of farming. The small number of swine in the western regions (west of the dashed line) should be noted. Canada statistics are for June 1, 1921.

corn crop of the United States. Corn is a warm climate crop, and it is owing mostly to the rare combination of humid and almost tropical summer weather, very fertile soils, and the level to rolling land surface, which can nearly all be cultivated, that the Corn Belt produces so large a proportion of the world's crop (Fig. 115).

Boundaries

The western and northern boundaries of the Corn Belt are climatic, whereas the eastern and southern boundaries are owing to topography and soil. In general, the boundaries have been drawn where the production of corn falls below 3,000 bushels per square mile, but along the western margin, where agricultural development is incomplete, possibilities of production have been taken into account, and the boundary has been drawn where the production of corn at present is much less. This western boundary follows, with only slight deviations, the line of 20 inches annual rainfall, the density of corn production diminishing rapidly beyond this line (Fig. 3).[4] The northern boundary follows more or less closely the line of 70 degrees mean summer temperature east of the Missouri and 69 degrees west of that river. To the north of this boundary hay and forage become more important than corn, and dairying replaces the production of beef cattle and hogs as the principal livestock enterprise. The eastern boundary follows the line where the more or less level

[4] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.

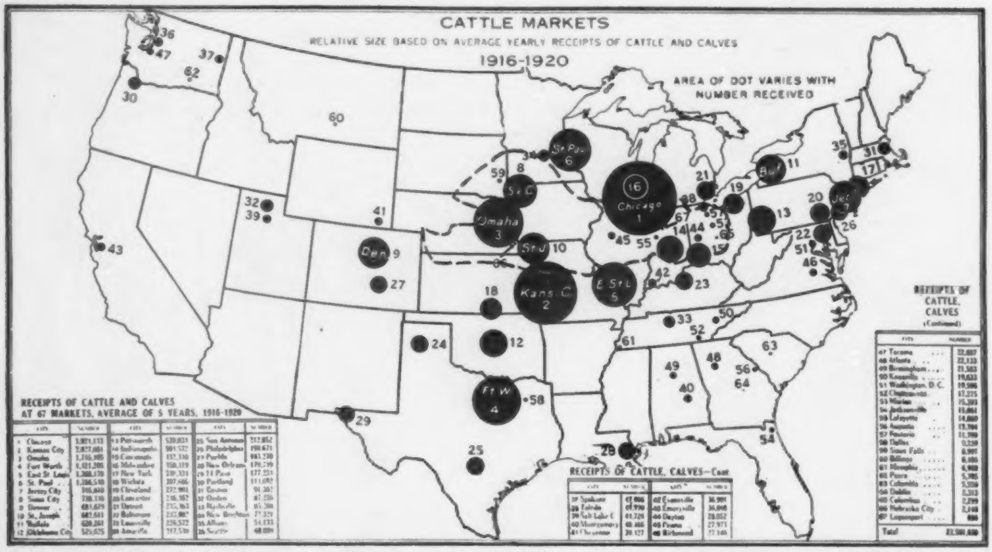


FIGURE 111.—Over 55 per cent of the receipts of cattle and calves at the 67 public stockyards in the United States during the years 1916 and 1920 were at points in the Corn Belt. The annual receipts at Chicago have been greater than any other market since the founding of the present yards in 1865. Kansas City ranks second and Omaha third. Most of the cattle received at these yards are sold to packers for slaughter, but large numbers are also sold to farmers for stockers and feeders. (U. S. Dept. of Agr. Yearbook, 1921.)

limestone lands of western Ohio give place to the hilly shale and sandstone lands of the eastern portion of that state. On these hilly and less fertile lands hay and pasture, used mostly for cattle and sheep, replace corn and hogs as the dominant system of farming. The southern boundary across Ohio, Indiana, and Illinois corresponds almost exactly with the southern limit of the Wisconsin glaciation; and across Missouri follows in a general way the northern limit of

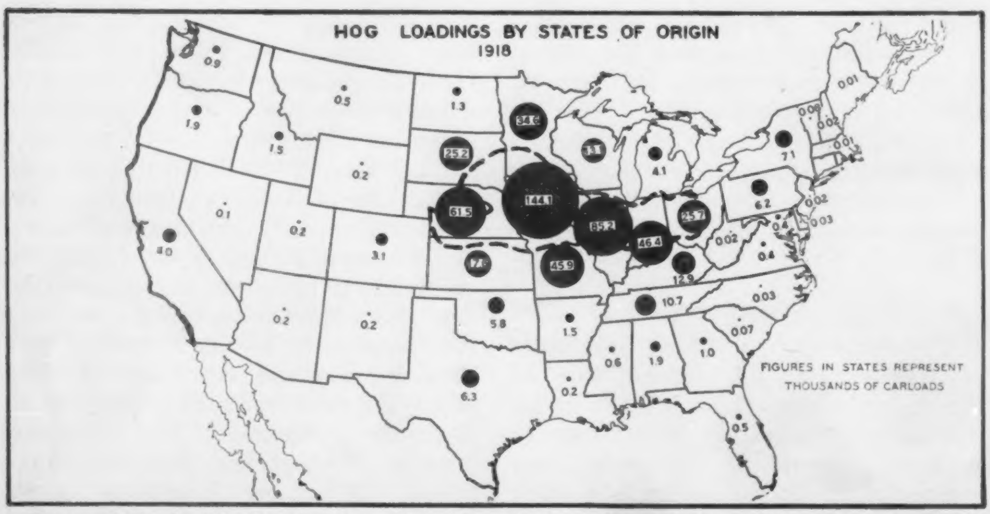
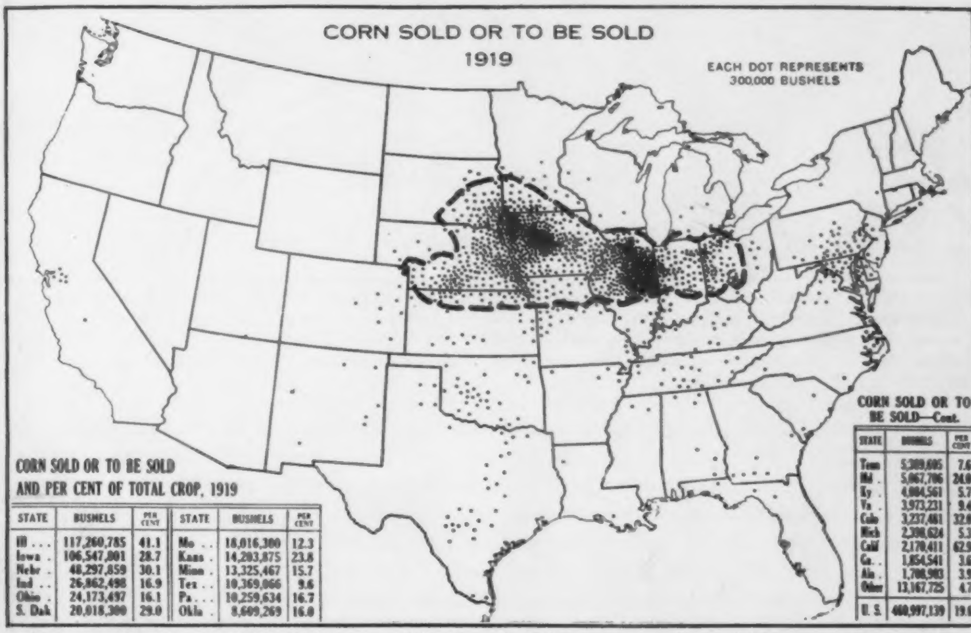


FIGURE 112.—In 1918 Iowa led in number of hogs loaded, with 144,105 cars; Illinois was second with 85,164 cars; Nebraska third with 61,489 cars; Indiana fourth with 46,362 cars, and Missouri fifth with 45,860 cars. These five Corn Belt states loaded about 70 per cent of the total loadings in the United States. Iowa loaded more than 25 per cent of all the hogs shipped during that year, whereas Missouri, which was fifth, loaded 8 per cent of the total. (U. S. Dept. of Agr. Yearbook, 1922.)

the hilly Ozark plateau. The unglaciated lands of southern Indiana and Illinois and the Ozark mountain lands are much less productive, particularly of corn, than the smoother, younger, richer lands to the north. In west-central Missouri and eastern Kansas the boundary is less definite and migrates back and forth with the relative price of wheat and corn. Across northern Kansas the southern boundary of the Corn Belt is very stable, and appears to be determined largely by the hot winds of July and August, which frequently dry out the corn plants and greatly reduce the yield.



CORN SOLD OR TO BE SOLD AND PER CENT OF TOTAL CROP, 1919

STATE	BUSHELS	PER CENT	STATE	BUSHELS	PER CENT
Ill . . .	117,260,785	41.1	Mo . .	18,016,300	12.3
Iowa .	106,547,801	28.7	Kans .	14,283,875	23.8
Nebr .	48,297,859	30.1	Minn .	13,325,467	15.7
Ind . .	26,862,498	16.9	Tex . .	10,369,066	9.6
Ohio .	24,173,497	16.1	Pa . . .	10,259,634	16.7
S. Dak	20,018,300	29.0	Okla .	8,609,269	16.0

CORN SOLD OR TO BE SOLD—Cont.

STATE	BUSHELS	PER CENT
Tenn	5,309,695	7.6
Md .	5,067,706	24.0
Ky .	4,084,561	5.7
Va .	3,973,231	9.4
Colo	3,237,481	32.0
Mich	2,308,624	5.3
Calif	2,170,411	62.9
Ga . .	1,854,541	3.6
Ala .	1,708,903	3.9
Other	13,167,725	4.7
U. S.	460,997,139	19.6

FIGURE 113.—In the Corn Belt most of the corn is fed to hogs, cattle, and horses on the same farm that it is grown; but a considerable quantity, amounting to 41 per cent of the crop in Illinois in 1919, and about 30 per cent in Iowa, South Dakota, and Nebraska, is sold to nearby farmers, is shipped to consumers in the South and East, is exported largely through Chicago and Atlantic ports, or is made into starch and glucose. (U. S. Dept. of Agr. Yearbook, 1921.)

Climate

Although the southern boundary is not climatic, except in Kansas, it is interesting to note that the warm season and summer temperatures are about six degrees higher than along the northern border. The mean lowest night temperature during the three summer months exceeds 58 degrees in all parts of the Corn Belt, and is generally 5 degrees warmer than this. These high night temperatures, in July seldom falling below 65 degrees, are important in the production of a full crop. The frostless season ranges in average length from 140 days in the northwestern corner of the Belt to 180 days along the southern border (Fig. 4).[5] On the other hand, the winter temperatures are rather low, mostly below freezing, and the frozen condition of the soil retards leaching by winter rains and snows, which has been so important a factor in depleting the fertility of the soils to the south.

The average annual precipitation in the Corn Belt varies from about 18 inches along the arid western margin to 40 inches in Ohio (Fig. 3).[6] However, the largest amount of rainfall during the

[5] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.
[6] *Ibid.*

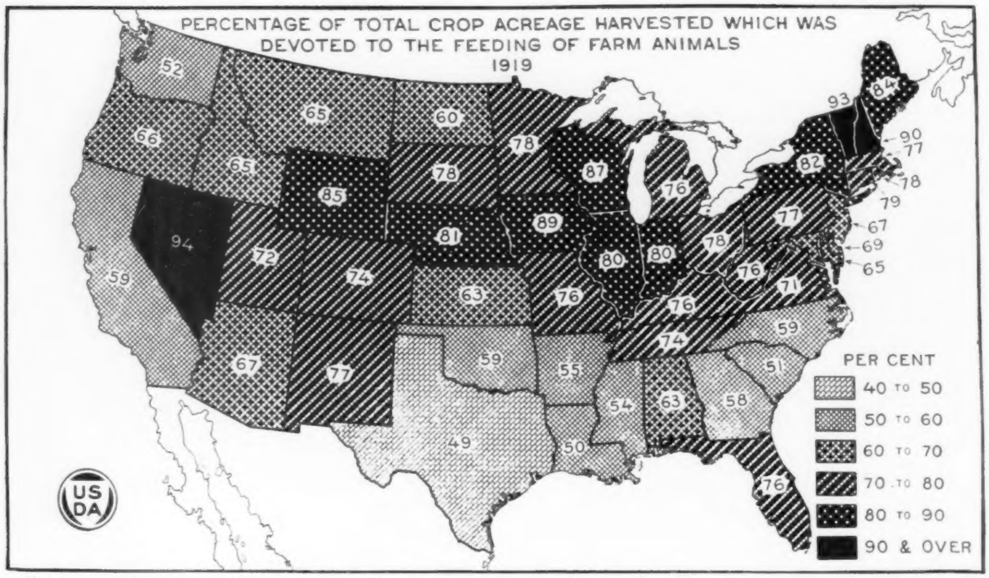


FIGURE 114.—About seven-tenths of the land in harvested crops in 1919 was used to produce forage for livestock. In the Corn Belt the proportion was over 80 per cent, and reached 89 per cent in Iowa. The total quantity of forage thus produced was sufficient to feed all livestock only a little more than half the year. Pasture supplies the remainder of the forage needed by our farm animals. (U. S. Dept. of Agr. Yearbook, 1923.)

warm season (April to September inclusive), about 24 inches, occurs in Missouri, southern Iowa, eastern Nebraska and Kansas, which are near the center of the Corn Belt. The smallest warm season rainfall, 15 inches, is along the western margin. This heavy rainfall during the warm season is of the greatest importance in the production of the corn crop (Fig. 116). Very important also has been the light rainfall of the winter season—less than one inch a month in the northwestern portion and under 3 inches a month in the southeastern portion of the Corn Belt—for it results in a lesser leaching of the soil than would occur in a region of heavy winter rains. This unusual combination of hot, humid summers, with moderately cold, dry winters constitutes the basic condition that accounts for the dominance of corn in this region.

The Surface of the Land

The large crop production in the Corn Belt is owing in part also to the fact that the land is practically all level to rolling (Fig. 5).[7] In general, only the

FIGURE 115.—A cornfield in the Corn Belt. Nothing is more beautiful in the eyes of a Corn Belt farmer than a well-cultivated cornfield in late summer. This picture, taken in Iowa, shows one of those large level fields so characteristic of the Central and Western Corn Belt. (Photo from O. C. Stine, U. S. Dept. of Agr.)

[7] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.

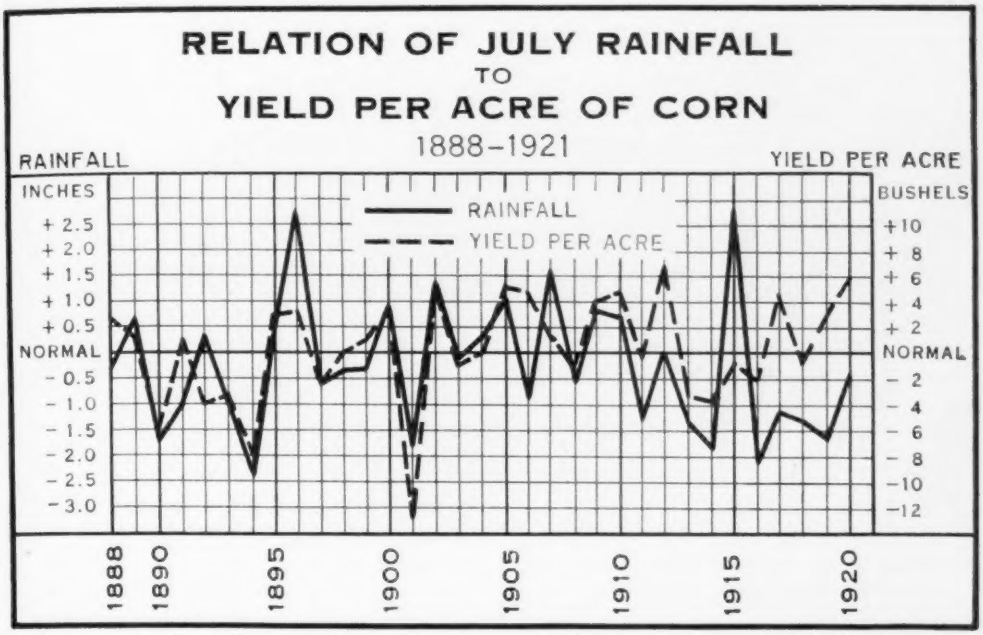


FIGURE 116.—The effect of rainfall during the month of July on the average acre yield of corn in Indiana, Illinois, Iowa and Missouri, of each year from 1888 to 1921, inclusive, is very marked. The divergence between the lines in recent years, it will be noted, is owing mostly to increasing yields per acre. (U. S. Dept. of Agr. Yearbook, 1921.)

narrow banks of the streams, or of their flood plains, are too steep for cultivation, certainly not over 10 per cent of the land in all. Very few regions in the world of so large extent have practically all their land topographically suitable for crop production. Much of the non-arable land of the Corn Belt is located along the sides of the V-shaped valleys of the streams that are cutting back into the upland in northern Missouri and southern Iowa.

Soils

All of the Corn Belt has been glaciated, except the plains of central and western Nebraska and northern Kansas. Consequently, the soils are young and have not had time to be leached of their fertility. Most of the soils are silt loams or clay loams in texture, derived largely from limestone drift (Fig. 6).[8] Silt loam is the most desirable soil texture for general farming, and soils derived from limestone are nearly always rich. Moreover, upon most of the surface of the central portion of the Corn Belt there has been deposited by the wind a mantle of very fertile silty soil, called loess by geologists, which varies from a few inches to many feet in thickness. The glacial action in the eastern and northern Corn Belt and this deposit of loess in much of the central and western portion has smoothed over many of the minor inequalities of the surface as well as contributed greatly to the fertility of the land.

The dark brown to black prairie soils which comprise about three-fourths of the Corn Belt are, in general, more fertile than the lighter colored forest soils in the eastern portion, and are specially adapted to corn, being warm, easily tilled and rich in humus. The forest soils of western Ohio and northern and central Indiana are, in general, very fertile soils, however; and in several counties in each of these states the pro-

[8] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.

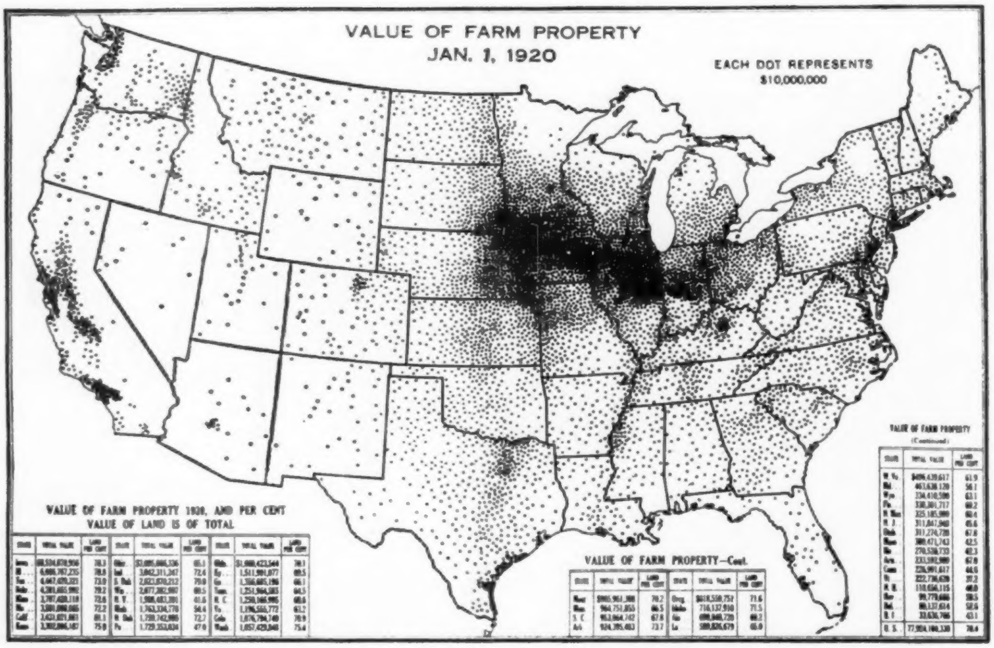


FIGURE 117.—Over one-third of the value of farm property in the United States is in the Corn Belt, and nearly two-fifths of the value of farm land. The average value of farm land per acre, January 1, 1920, was $148 in the Corn Belt, as compared with $40 in the Cotton Belt, $48 in the Hay and Pasture Region, and $21 in the Great Plains Region. Only in the South Pacific Coast Region does the value of farm property per square mile and of farm land per acre ($114) approach the values in the Corn Belt. (U. S. Dept. of Agr. Yearbook, 1921.)

portion of the land in corn and the yield per acre is as high as in the prairie portion of the Corn Belt.

The farm land (excluding buildings) in the Corn Belt had an average value, January 1, 1920, of $148 per acre, as compared with $40 in the Cotton Belt, $55 in the Corn and Winter Wheat Region to the south, and $48 in the Hay and Pasture Region to the north (Fig. 2).[9] Although the Corn Belt includes only 8 per cent of the land of the United States, the value of the farm land of the Corn Belt in 1919 was nearly 40 per cent of that of the entire United States (Fig. 117). It is mostly to the superior fertility of the soils of the Corn Belt and the large proportion of the land that is arable that this higher value must be attributed.

LAND UTILIZATION

About one-fourth of the Corn Belt was originally forested, the forests covering practically all of the Ohio and Indiana portion with narrow bands extending along the rivers to the westward. The central and western Corn Belt, except these woodland strips along the streams, was a vast, verdant prairie (Fig. 9).[10] Today less than 8 per cent of the land area is in forest, mostly farm woodlots (Fig. 10);[11] and 22 per cent is in pasture, composed almost entirely of tame grasses, except along the semi-arid edge; while 60 per cent is in crops, a larger proportion than in any other region (Fig. 84).[12] Ninety per cent of the land area is in farms and 75 per cent is improved land

[9] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.

[10] *Ibid.*

[11] *Ibid.*

[12] ECONOMIC GEOGRAPHY, July, 1927, issue; "Agricultural Regions of North America," Part III, by the author.

(Fig. 11).[13] Roads, railroads, cities, and villages occupy most of the land not in farms.

The possibility of increasing the crop acreage is, therefore, not as great as in other regions. About half of the forest and woodland, or 6 million acres, is potentially arable, and two-thirds of the pasture, or about 20 million acres. This would theoretically permit an increase in crop land of 30 per cent, but that most of the tillable pasture land should ever be used constantly for crops is inconceivable, as it would greatly increase the amount of labor required for the care of the livestock, and would tend to decrease the fertility of the soil.

The Crops

Of the five major crops that are grown in the United States—corn, cotton, wheat, oats and hay, which jointly compose 87 per cent of the total crop acreage —four are extensively grown in the Corn Belt. Its system of agriculture is better balanced than that of any other large agricultural region. Corn constituted 42 per cent of the acreage and 54 per cent of the value of all crops in the Corn Belt in 1919; most of the remaining acreage is almost evenly divided between oats (18 per cent), wheat (17 per cent) and hay (16 per cent). The principal hay crops are timothy and clover, grown separately or mixed, and alfalfa. Winter Wheat is the leading small grain crop in the southern portion of the Corn Belt, and oats in the northern portion (Figs. 14 [14] and 118). The line separating winter wheat from oats follows in a general way that of 23 degrees average winter temperature. This division is doubtless owing also in part to the fact that in the southern Corn Belt the corn can be gotten off the ground in time to seed wheat in the fall, whereas farther north, where this cannot be done, it is necessary to use a spring sown crop. Moisture conditions similarly separate the Corn Belt into a western portion in which alfalfa or the native wild grasses are the leading hay crops, and an eastern portion in which timothy and clover are the more important (Figs. 17 and 19).[15] This dividing line, or rather transition zone, crosses the Corn Belt near the Missouri River and corresponds with an average ratio of precipitation to evaporation during the six months warm season of about 60 per cent. Probably the lesser lime content in the soils of the more humid portion of the Belt east of the Missouri River is also an important factor in causing this division of territory.

Potatoes, sweet potatoes (to a very small extent), vegetables, and fruits are grown in the Corn Belt, mostly for home use or to supply a nearby town. Jointly these crops constitute one per cent of the acreage of all crops and four per cent of the value. A little barley is grown along the northern margin of the belt (constituting 1.2 per cent of the acreage of all crops in 1919 and 0.8 per cent of the value), and a little rye on the sandy lands of northern Indiana, western Illinois, and central Nebraska. Tobacco is an important crop in four counties in Ohio.

Pasture

The acreage in pasture (36,000,000 acres) is about equal to the acreage of corn. Moreover, the pastures have a higher carrying capacity, on the average, than those of any other agricultural region. Probably nearly half the pasturage consists of timothy or clover, grown in rotation with crops and used for pasture a year or two when the land is not needed for hay or other crops. The remaining half, or more, is permanent blue grass pasture, or the native grassland in the western sub-humid and semi-arid portions of the Belt. These pastures provide a large proportion of the summer feed, but the cattle are generally supplied with supplementary

[13] Economic Geography, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.
[14] *Ibid.*
[15] *Ibid.*

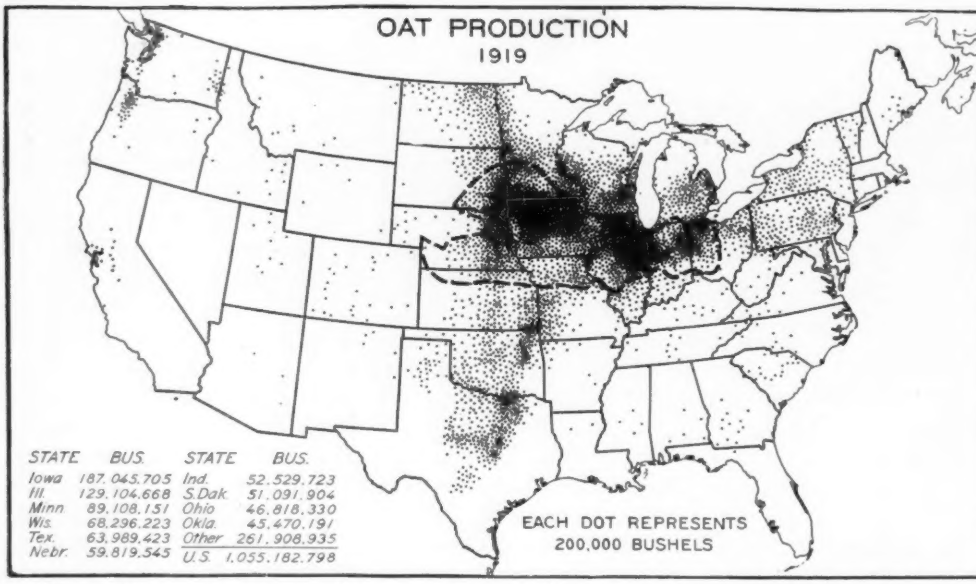


FIGURE 118.—Oats rank second to corn among the feed crops. The threshed grain is valued especially for feeding work animals. Production of oats is heaviest in the northern portion of the Corn Belt, but the crop is very important also in the Hay and Dairying Region and in eastern Kansas, Oklahoma and Texas. (U. S. Dept. of Agr. Yearbook, 1923.)

grain in late summer or early autumn, when the bluegrass pastures especially are likely to suffer from drought. Most of the woodlots are also used for pasture, but the carrying capacity is very small, ten acres of woodlots being required, probably, to supply as much sustenance as one acre of rotation pasture or good bluegrass pasture.

Livestock

If the acreage in pasture be added to the 84 per cent of the crop land used to produce feed, it appears that about 90 per cent of the agriculturally productive land of the Corn Belt is utilized to feed farm animals. The farm animals are principally horses, beef cattle, dairy cattle, hogs and poultry, constituting 22, 27, 22, 19 and 5 per cent respectively of the total animal units in the region. However, owing to the more rapid turnover, the value of the hogs produced in 1919 was about 800 million dollars, and of poultry and eggs 300 million, as compared with 270 million for beef cattle, 250 million for dairy products, and 40 million for horses and mules, other than the value of their labor. The value of the product of the hogs, therefore, almost equalled the value of all other livestock raised and livestock products.

The farm value of all livestock and livestock products produced in 1919 amounted to about $1,700,000,000, or roughly $2,000 per farm. The value of the crops not used to feed livestock was about $650,000,000 in 1919, or $750 per farm. Nearly three-fourths of the income of the Corn Belt farmer, in other words, is derived from livestock and livestock products and one-fourth from sale of crops. Out of this gross income of about $2,750 he had to pay the cost of production. Among these items of cost may be mentioned: labor about $300 per farm, fertilizer $10, taxes probably $300, and rent, if a tenant, perhaps $900 per farm, either in cash or kind. In the year 1919 prices were near the peak and the year was an unusually prosperous one for Corn Belt farmers.

The horses are distributed almost uniformly throughout the Corn Belt,

FIGURE 119.—Beef cattle on clover pasture in the Corn Belt. Red clover is noted as a "soil builder." Plowing under the entire crop secures the greatest possible manurial value, but as a rule it is more economical to graze the clover and plow under the residue. Most of the clover is grown mixed with timothy. The picture shows a herd of beef cattle, probably shipped in from the West, grazing in a rich Corn Belt pasture. (U. S. Dept. of Agr. Yearbook, 1923.)

because they are used solely for power (Fig. 68).[16] The beef cattle are found principally in the prairie portion (Fig. 24),[17] because here is the cheapest pasture. The dairy cattle are densest along the northern margin and in the eastern portion of the belt, largely because of the cooler temperature and the proximity to the cities (Fig. 23).[18] The hogs are densest, in general, where the corn is most abundant and cheapest (Fig. 110). The thinner distribution within a radius of 100 miles of Chicago is owing to the higher price of corn in this section, because of the low freight rates to Chicago, the great market, where the corn is made into starch, glucose, corn meal, or breakfast food, is shipped east or south for feed, or is exported. Beyond this Chicago district the corn is concentrated into hogs instead, which, having a higher value per unit of weight, can better stand the cost of transportation. The poultry, like the hogs, are found where the price of corn, relative to the price of meat, is lowest (Fig. 93).[19]

SYSTEMS OF FARMING

In the Corn Belt, as in the Cotton Belt, there is only one prevalent system of farming. This system, based on corn, hogs and cattle, with a small grain grown in part as a nurse crop for timothy and clover, is one of the most satisfactory in the United States from the standpoint both of securing a relatively even distri-

FIGURE 120.—Fattening hogs on a Corn Belt farm. The production of hogs in the United States goes hand in hand with corn production. No other crop product seems to be so well suited to the growth and fattening of this farm animal. Hogs are abundant in the States almost in direct proportion to the quantity of corn produced. (U. S. Dept. of Agr. Yearbook, 1923.)

[16] ECONOMIC GEOGRAPHY, January, 1927, issue; "Agricultural Regions of North America," Part II, by the author.

[17] ECONOMIC GEOGRAPHY, October, 1926, issue; "Agricultural Regions of North America," Part I, by the author.

[18] *Ibid.*

[19] ECONOMIC GEOGRAPHY, July, 1927, issue; "Agricultural Regions of North America," Part III, by the author.

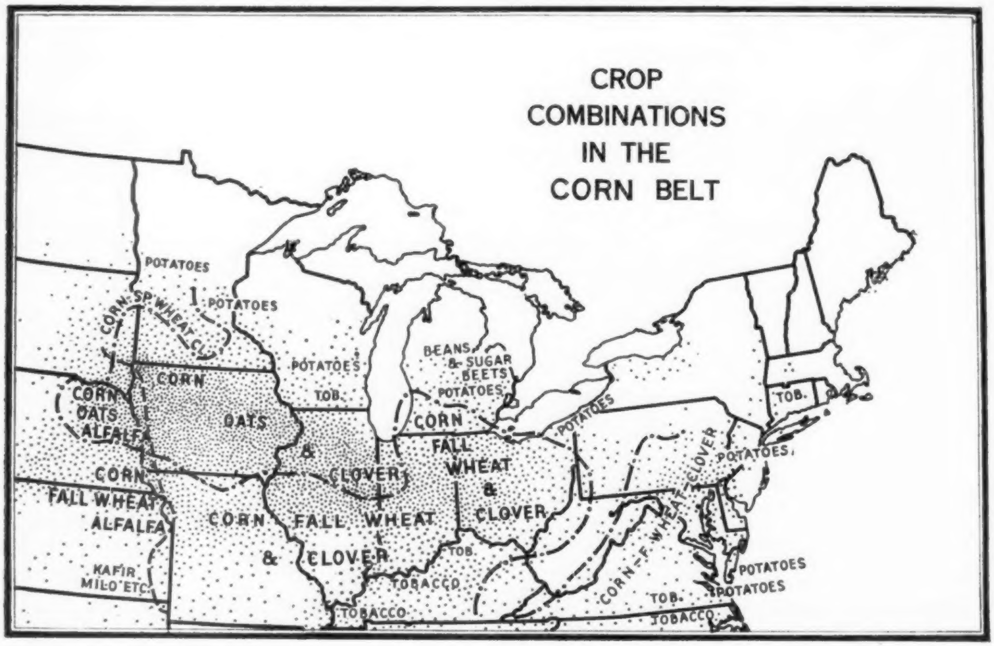


FIGURE 121.—The dots indicate corn acreage. The broken lines mark off the regions of crop combinations. Intertilled crops other than corn find their place for the most part outside of the true Corn Belt. East of the Missouri River the dominant hay crop is clover or timothy; west of that river it is mostly alfalfa. In the southern Corn Belt, and also in the northern portion east of Lake Michigan, winter wheat is a more important grain crop than oats; but in the northern Corn Belt, west of Lake Michigan, oats almost replace wheat. (U. S. Dept. of Agr. Yearbook, 1921.)

bution of labor throughout the year and of maintaining the high productivity of the land. It probably yields also a larger net income than any other major system of farming in the United States.

Rotations

The usual cropping system consists of a cultivated crop (corn), which is followed by a small grain crop (wheat or oats), in which a hay crop (timothy and clover) is usually seeded, in the eastern and central portion of the Belt (see Fig. 121). The alfalfa, which in the western portion of the Belt follows small grain, is usually seeded separately. In the southeastern portion of the Corn Belt the rotation is commonly four years in length, being corn, winter wheat, clover, timothy. The timothy grass is sometimes pastured the entire fourth year, instead of being cut for hay, and is usually pastured in the fall after being cut for hay. Frequently the timothy is allowed to lie the fifth year for pasture and occasionally the sixth year, by which time bluegrass is likely to become well established in the field. This is true not only of the southeastern section of the Corn Belt, but also of most of the region east of the Missouri River.

In the northeastern section of the Corn Belt oats replace a part of the wheat. In the south-central portion, especially in southwestern Illinois, both corn and wheat may be grown two or more years in succession, and the hay crop, commonly timothy, becomes less important. In northern Missouri and southern Iowa, on the other hand, a more definite rotation is followed and timothy and clover have a regular place in the rotation. In the north-central Corn Belt oats largely replace wheat in the rotation, and more clover is grown. Soy beans, however, are now partially replacing oats. In the southwestern Corn Belt the rotation is likely to be corn,

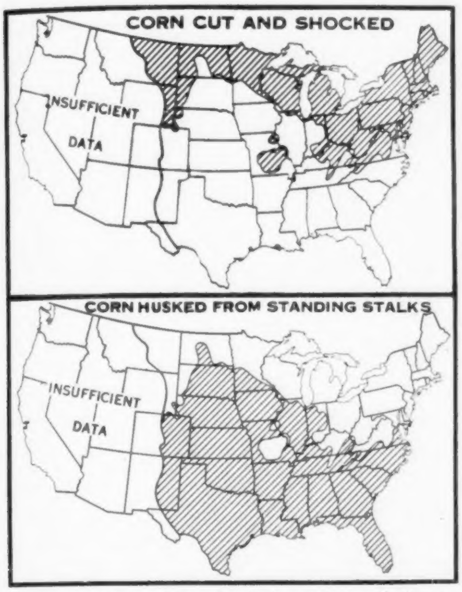


FIGURE 122.—The shaded portions of the two maps show the sections of the United States where cutting and shocking corn (above) and gathering it from standing stalks (below) are the more common practices. "Husked" is used in the figure, although in the South corn is often "jerked." It will be noted that in all except the Ohio section of the Corn Belt, husking from the standing stalk is the usual method of harvesting. But the introduction of the corn binder and the coming of the corn borer seem destined greatly to increase the acreage cut and shocked and also the acreage cut for silage. (Maps from U. S. Dept. of Agr. Yearbook, 1921.)

corn, wheat, wheat, alfalfa, which is usually allowed to grow for several years; and in the northwestern Corn Belt the common rotation is corn, corn, oats, with or without alfalfa. In the Minnesota and South Dakota portions of the Corn Belt the wild grasses are depended upon largely for hay, only a little alfalfa being grown in the South Dakota portion, and a little timothy and clover in the Minnesota portion of the Corn Belt.

In the Ohio portion of the Corn Belt the corn is nearly all cut and shocked, the fodder being fed to livestock (Figs. 122 and 123), but in the central and western portions, to save labor, the corn is mostly husked from the standing stalk or hogged down (Figs. 124 and 125). The wheat and oats are commonly harvested with a binder and threshed by a stationary steam or gas engine outfit, but recently the small combine has rapidly come into use. The hay is cut with a mower, raked with a horse rake, stirred with a tedder, loaded onto the wagon with a loader, and lifted into the barn with a large fork.

Special Enterprises

There is a minor center of fruit production, principally apples, on the rolling blufflands along the Missouri River in northwestern Missouri and adjacent portions of Kansas and Nebraska. In southwestern Ohio, as already noted, there is a minor center of tobacco production, and sweet corn for canning is of local importance in several counties in the region. One county in Iowa produces most of the pop corn grown in the United States. But even in these relatively insignificant districts, the corn, small grain, hay, hog and cattle system of farming is of greater importance than any of these local specialties. This general system of farming is so well adapted to the physical conditions and so profitable that it prevails more completely over the entire Corn Belt than any other system of farming of comparable extent elsewhere in the United States, except the cotton and corn system in the Cotton Belt.

SIZE AND TENURE OF FARMS

The size of farms in the Corn Belt increases from east to west. In the Ohio and Indiana portion of the region the farms averaged 100 acres in size in 1920, of which 70 acres were in crops. In the Illinois and Iowa portion the farms averaged 157 acres in size, of which 120 acres were in crops; while in the Nebraska-Kansas portion the farms averaged about 200 acres in size, of which about 133 acres were in crops. The smaller farms in the Ohio-Indiana portion are probably due to the fact that this area was originally in forest, which required many years and a heavy expense to clear, also to the fact that this area was settled before the use of modern labor-saving machinery became prevalent. The prai-

FIGURE 123.—A corn harvester at work. This machine saves a large amount of labor, and more corn is being cut now than formerly, both for silage and for fodder. (U. S. Dept. of Agr. Yearbook, 1921.)

rie land of Illinois and Iowa was easily broken, but modern farm machinery was only just coming into use when settlement occurred, and the settlers for the most part lacked money to buy large amounts of land. When Nebraska and Kansas were settled, the introduction of machinery had made larger farm units feasible, and probably the settlers possessed a little more capital.

The trend throughout the Corn Belt today is toward larger farms. In 1900 the average size of farms in the Corn Belt was 143 acres, in 1910 the average size was 149 acres, and by 1920 the average size had increased to 153 acres. The farms are still larger today. The average increase in acreage of harvested crops was from 90 acres in 1909 to 100 acres in 1919. This increase was made possible by more efficient farm machinery and the use of more power, also undoubtedly by more efficient management.

It is interesting to compare the average area of crops per farm in Iowa, the most typical Corn Belt state, with that in the mountains of eastern Kentucky, where corn is an even more dominant

FIGURE 124.—Husking corn from the standing stalks in northern Iowa. In the northern portion of the Corn Belt, west and southwest of Lake Michigan, the corn does not mature in time to seed wheat in the fall, so oats are sown in the spring, followed commonly by timothy and clover, and the corn stalks are allowed to stand in the field. Husking from the standing stalk requires much less labor than cutting and shocking; hence the large acreage of corn in the central and western Corn Belt is harvested principally by this method (see Fig. 122). (Photograph by M. O. Cooper, U. S. Dept. of Agr.)

crop. The average for Iowa is 101 acres, of which 42 were in corn, as compared with 16 acres in the Kentucky mountains, of which 9 were in corn. The difference in production per farmer is still greater, the Iowa farmer growing 1,740 bushels of corn on the average in 1919 as compared with 184 bushels in eastern Kentucky. It is this great productivity per man which explains the opulence of Iowa, and the small productivity per man, the poverty of eastern Kentucky. Physical conditions are, of course, the principal cause of this difference, but there is also undoubtedly a tendency for the best farmers to get the best land, for on such land their superior skill has the greatest effect.

FIGURE 125.—Harvesting corn with hogs in the Corn Belt. Hogging down corn is a successful and economical method of fattening hogs. Most of the stalks, it will be noted, have been broken down by the hogs. The barn in the background is typical of the newer type of barns in the Corn Belt, but is smaller than usual. (Photograph by L. B. Beeson, U. S. Dept. of Agr.)

LAND TENURE

About 59 per cent of the farms in the Corn Belt are operated by their owners, 40 per cent by tenants, and 1 per cent by managers. The tenant farms are relatively most numerous on the richest land in central Illinois and northwestern Iowa, the percentage of farms operated by tenants rising to 60 per cent in these districts, and, as tenant farms are larger than owner farms, the proportion of improved land operated by tenants is in some counties as high as 70 per cent (Fig. 126). On the poorer soils of northern Missouri and southern Iowa, on the other hand, only 20 to 40 per cent of the improved land is farmed by tenants. The poorer the soil, the smaller the probability that the farm can support both an owner and a tenant.

Tenants in the Corn Belt, however, are a very different class, in general, than in the Cotton Belt, where the percentage of tenancy is equally high and on the richest land is even higher. In the Cotton Belt the tenants are mostly negroes and poor whites, relatively few achieving ownership, whereas in the Corn Belt nearly half the tenants are sons, sons-in-law, or otherwise related to the farm owners, and a large proportion will in the course of their lives save enough money to purchase and eventually pay for the farm. Then they, too, retire to town, often the county seat, usually at the behest of the wife or daughter and a new generation repeats the laborious and parsimonious process of paying for the farm. With the passage of each generation a large proportion of the value of the land, commonly the entire price of the farm, is thus drained away to the cities.

The greatest need of this greatest farming region in the world is the devel-

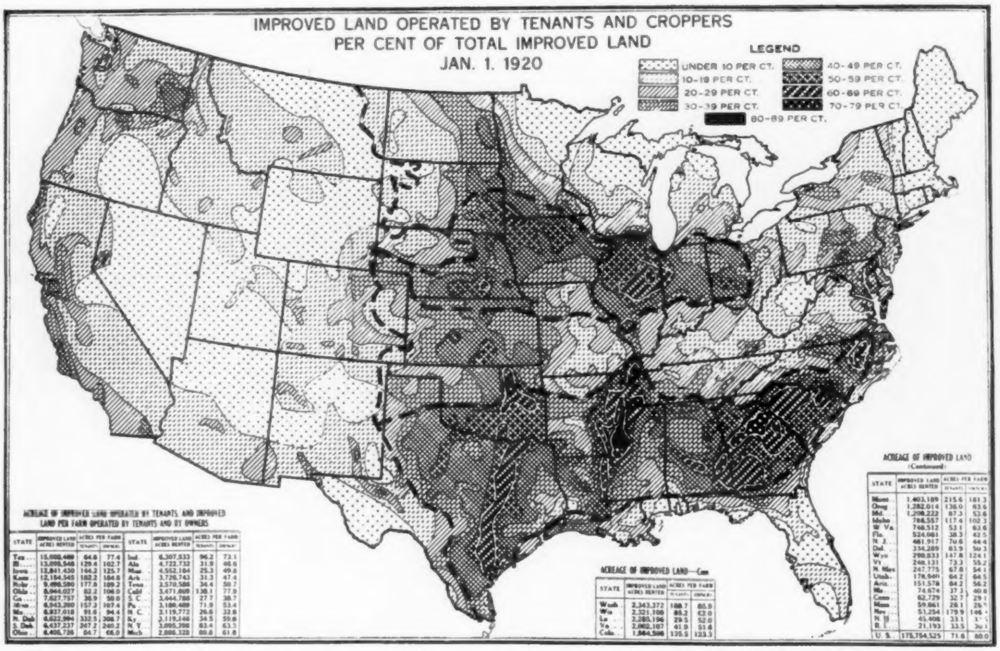


FIGURE 126.—This map shows the relative extent of tenancy from the standpoint of improved land. The principal areas having over 60 per cent of the improved land operated by tenants are the richest portions of the Corn Belt and of the Cotton Belt, which regions have been enclosed by broken lines on the map. These are our most productive areas in which many of the farmers or planters can afford to retire to town and be supported by the rent of their farms. The small proportion of improved land operated by tenants in the hills of New England, in the southern Appalachian Mountains, on the sandy lower coastal plain of the South, and in the arid areas of the West is noteworthy. The dashed north-south line is the eastern boundary of the Arid Grazing and Irrigated Crops Region. (Map adapted from 1921 Yearbook, U. S. Dept. of Agr.)

opment of rural social institutions and of an attitude toward rural life that will cause the older generation to be satisfied to spend their declining years on the farm and pass on to the next generation the wealth and experience they have accumulated. This would result in better homes and a more satisfactory rural culture (Figs. 127 and 128). It would undoubtedly help the younger generation to see in agriculture a more adequate and satisfying opportunity. This many of the more ambitious young men do not see at present.

THE PEOPLE

The population of the Corn Belt in 1919 was 12,300,000, which was 12 per cent of the population of the United States. Forty per cent of these people lived in the open country or in unincorporated hamlets and villages, 16 per cent in incorporated villages of less than 2,000 population, and 44 per cent in places of 2,500 people or more, mostly in cities. If the village population may be considered to be half rural in interests, the people of the Corn Belt may be classified roughly as half rural, half urban in point of view.

Race

The farmers of the Corn Belt are mostly of native American stock, those in the southern part being descendants largely of settlers from Virginia and Pennsylvania, while in the northern portion most of the farmers are of New England and New York ancestry. There are also many farmers of German descent, notably in western Ohio, in northern Illinois, in the region around St. Louis, and in eastern Nebraska. Scandinavian farmers are found in many communities

FIGURE 127.—A pioneer home in Iowa. This house was constructed before the Civil War. It is made of logs, flattened on the side, and chinked with plaster. The early settlements in Iowa were made near streams, not only because of accessibility, but also because the forests that bordered the streams provided logs for the houses and wood for the fireplaces. (Photograph from O. C. Stine, U. S. Dept. of Agr.)

along the northern margin of the Corn Belt, while farmers of English and Irish ancestry are largely confined to Illinois, Iowa, and eastern Kansas. There is a large settlement of Russian farmers in southeastern South Dakota, also of Bohemians in eastern Nebraska. These various nationalities intermarry to a large extent, and more or less lose their identity in the second or third generation.

Religion and Education

The Corn Belt may be characterized as a region of progressive rural Protestantism. Most of the farm population belong to one of the evangelical churches. Only 1½ per cent of the rural population of the Corn Belt is illiterate (1 per cent for whites), as compared with 7 per cent in the Corn and Winter Wheat Belt to the south and 2.7 per cent in the Hay and Pasture region to the north, where there is a much larger proportion of foreign born illiterates.

The Trend in Production and Welfare

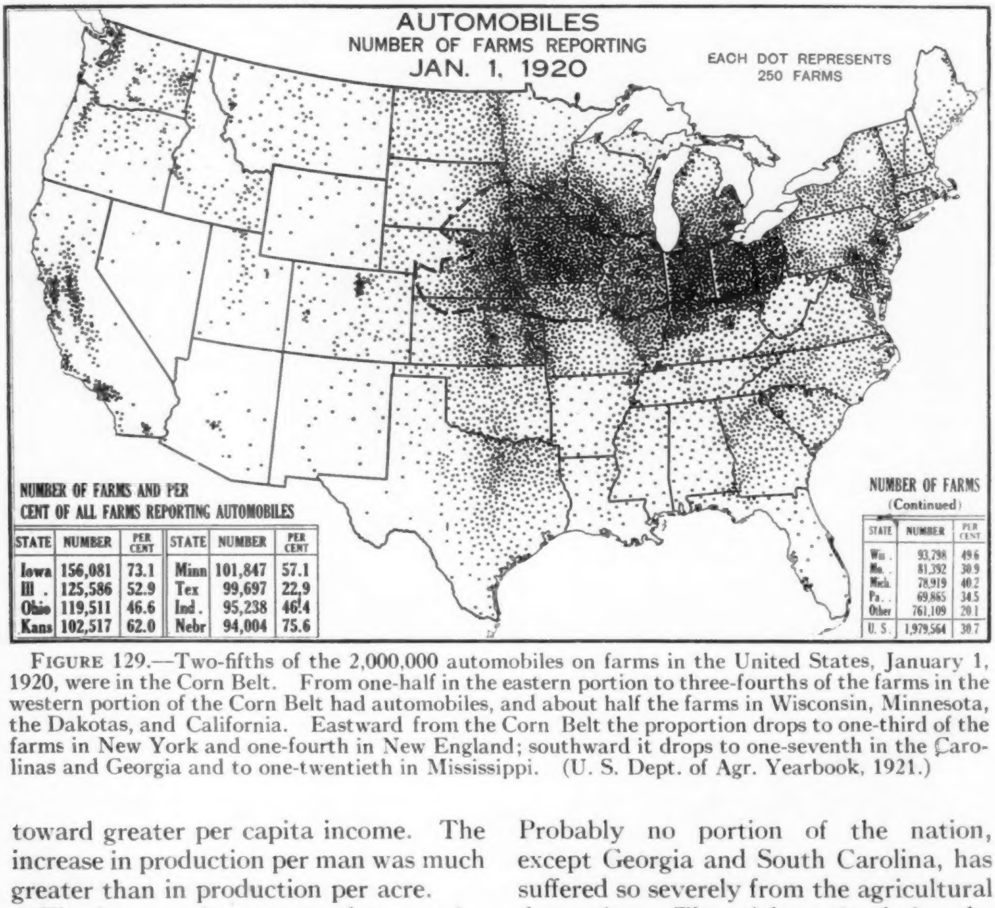
The number of farms in the Corn Belt decreased 8 per cent between 1900

FIGURE 128.—A modern farmstead in Iowa. A comparison of this picture with that above shows the great progress that has been made in a half century in providing pleasant homes, as well as adequate farm buildings, in the western portion of the Corn Belt. (Photograph from O. C. Stine, U. S. Dept. of Agr.)

and 1920, and the farm population about 13 per cent. The acreage of improved land remained stationary during the period, but that of crop land increased nearly 10 per cent. Acre-yields of the crops also increased slightly. It is evident that in the Corn Belt, as in most parts of the United States, the trend was toward the utilization of more capital, especially power machinery, and less labor on the farms; toward greater individual efficiency of production and consequently, at least in the long run, toward greater per capita income. The increase in production per man was much greater than in production per acre.

The increase in tenancy does not indicate a tendency toward the continental European peasant agriculture, but rather toward the English system of tenancy, with its large farms, the tenant finding it more profitable at present to invest his funds in machinery, equipment and livestock than in expensive land. Tenancy in the Corn Belt, however, differs from that in England in that the tenant aspires to, and usually succeeds eventually in purchasing a farm. It is a step in the ladder from farm laborer to owner.

At present rural conditions in the Corn Belt are depressing. Land in 1925, according to the Census, was valued at only about half as much as in 1920. Not only many farmers but also many rural banks have gone into bankruptcy. Probably no portion of the nation, except Georgia and South Carolina, has suffered so severely from the agricultural depression. The richest land in the world can be bought often for less than it would cost to replace the farm buildings. Nevertheless, the farmers of the Corn Belt still buy automobiles more freely, probably, than farmers in any other portion of the United States (Fig.



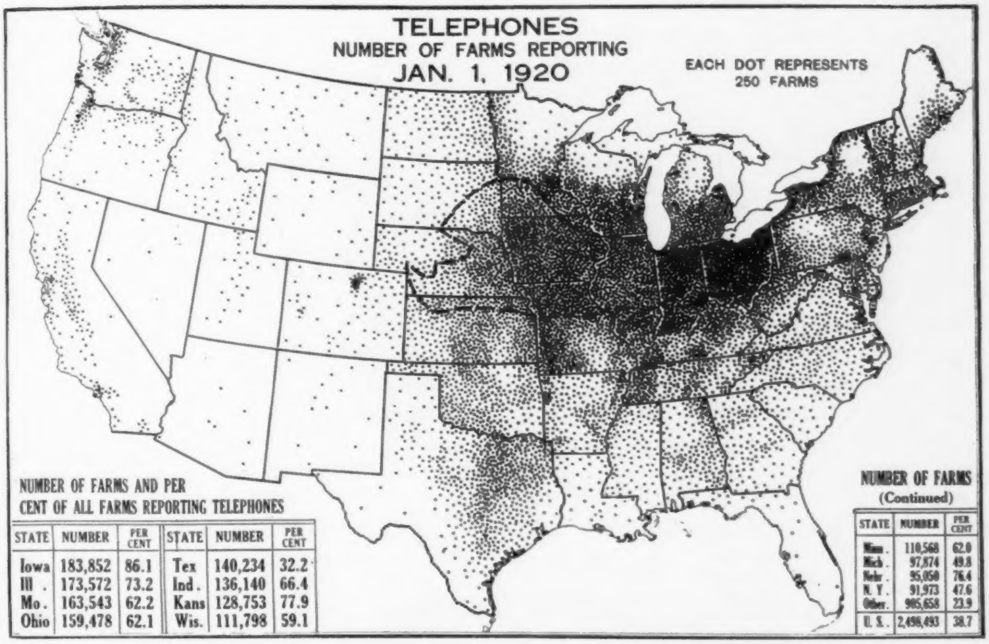
NUMBER OF FARMS AND PER CENT OF ALL FARMS REPORTING AUTOMOBILES

STATE	NUMBER	PER CENT	STATE	NUMBER	PER CENT
Iowa	156,081	73.1	Minn	101,847	57.1
Ill .	125,586	52.9	Tex	99,697	22.9
Ohio	119,511	46.6	Ind .	95,238	46.4
Kans	102,517	62.0	Nebr	94,004	75.6

NUMBER OF FARMS (Continued)

STATE	NUMBER	PER CENT
Wis .	93,798	49.6
Mo. .	81,392	30.9
Mich.	78,919	40.2
Pa. .	69,865	34.5
Other	761,109	20.1
U. S.	1,979,564	30.7

FIGURE 129.—Two-fifths of the 2,000,000 automobiles on farms in the United States, January 1, 1920, were in the Corn Belt. From one-half in the eastern portion to three-fourths of the farms in the western portion of the Corn Belt had automobiles, and about half the farms in Wisconsin, Minnesota, the Dakotas, and California. Eastward from the Corn Belt the proportion drops to one-third of the farms in New York and one-fourth in New England; southward it drops to one-seventh in the Carolinas and Georgia and to one-twentieth in Mississippi. (U. S. Dept. of Agr. Yearbook, 1921.)



STATE	NUMBER	PER CENT	STATE	NUMBER	PER CENT
Iowa	183,852	86.1	Tex	140,234	32.2
Ill.	173,572	73.2	Ind.	136,140	66.4
Mo.	163,543	62.2	Kans	128,753	77.9
Ohio	159,478	62.1	Wis.	111,798	59.1

STATE	NUMBER	PER CENT
Minn.	110,568	62.0
Mich.	97,874	49.8
Nebr.	95,050	76.4
N. Y.	91,973	47.6
Other.	905,658	23.9
U. S.	2,498,493	38.7

FIGURE 130.—Telephones are most common on the farms of the Corn Belt and of Kansas, in which region from 60 to 90 per cent of the farms, varying with the state, possess this convenience. In the Hay and Pasture, the Spring Wheat, and the Pacific Coast Regions, about half the farms have telephones; in Texas and Oklahoma about one-third of the farms; in the Corn and Winter Wheat Region (except Kansas), in the Great Plains and the Rocky Mountain Regions about a quarter of the farms; but in the Cotton Belt, east of Texas and Oklahoma, only 5 to 15 per cent. The proportion of the farms possessing a telephone is indicative of the general diffusion of rural progress and prosperity. (U. S. Dept. of Agr. Yearbook, 1921.)

129). Nearly all the farms have telephones (Fig. 130), and a very large proportion have radio outfits. The people of the Corn Belt, despite the agricultural depression, persist in pushing onward toward the better day.

RELATION OF TAURINE CATTLE TO CLIMATE *

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THE climate of northwestern Europe under which the *Bos taurus* domestic breeds of cattle have originated is comparatively mild. The mean monthly temperature ranges from 35° to 63° F. and the mean monthly relative humidity fluctuates around 80 per cent throughout the year. These European domestic cattle, although originating under a mild, humid climate, have not been limited to it in their distribution in other countries. In the United States they are found in environments very dissimilar, both in topography and climate, to that of their native home and are capable of thriving and reproducing under the new conditions. This adaptability of the European cattle to strange environments forms an interesting field.

Ancestry of Domestic Cattle

The Giant Ox (*Bos taurus primigenius*) seems to be the most probable ancestor of the northern European domestic breeds of cattle.[1] This wild ox roamed in the forests of northern and central Europe and was distinctly a temperate, deciduous forest dweller and not a prairie or grassland inhabitant as is the general conception. Lydekker (1898) has described this ox as being a very massive animal, standing six to seven feet at the shoulders, long in body and rather short legged. In summer it was dark brown to black in color and turned grey in winter. It lived mainly on shrubs and herbs and migrated to the valleys in winter. The descendants of this Giant Ox are found throughout the temperate regions, but unlike their ancestor have become inhabitants of the grassland, subtropical and semi-arid regions.

INFLUENCE OF CLIMATE UPON DISTRIBUTION OF DOMESTIC CATTLE IN UNITED STATES

In studying the influence of climate upon the distribution of cattle in the United States it was necessary to use only pure-bred cattle, as they are the only animals which are certain to carry all of the inherent characteristics developed within the domestic breeds in their native homes. The breeds selected for this study were the Hereford, Shorthorn, and Angus for beef cattle and the Holstein and Jersey for dairy cattle.[2] The beef breeds and the dairy breeds each show a peculiarity in their distribution and will be discussed separately.

* Contribution from the Department of Animal Husbandry and from the Zoölogical Laboratories (No. 302) of the University of Illinois.

[1] According to Morse (1910) most investigators have narrowed the ancestry of the *Bos taurus* domestic cattle to two species, viz., *Bos taurus primigenius* or the Giant Ox, and *Bos taurus longifrons* or the Celtic Ox. No fossil remains have been found of the Celtic Ox, whereas many fossils of the Giant Ox have been found throughout northern Europe. It is believed that the Celtic Ox was a product of the domestication of the Giant Ox.

[2] The Guernsey breed in this country unfortunately fell into the hands of millionaire fanciers and up until recent years have been higher in price than any of the other dairy breeds. The fact that they are not as numerous as the Jersey or Holstein breeds is due in the main to this handicap imposed upon them. They come from the same geographical regions as do the Jerseys and have originated under practically the same environmental conditions. Hence, if given an opportunity in this country, they would no doubt follow a distribution similar to that of the Jerseys. The Ayrshire breed in this country has also been handicapped in that it is intermediate between the Holstein and Jersey breeds in the production of milk and butterfat. It can compete neither with the Holstein for the whole milk market nor with the Jersey for the cream market, and hence is limited to the east where it is found in the main on the estates of the wealthier breeders. (See Figure 10.) Owing to the characteristics of this breed and to the environment under which it originated, it is the opinion of the author that if this breed were given a chance in this country, it would follow in a general way a distribution similar to that of the Holsteins.

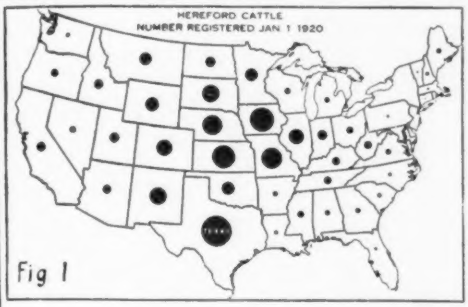


Fig 1

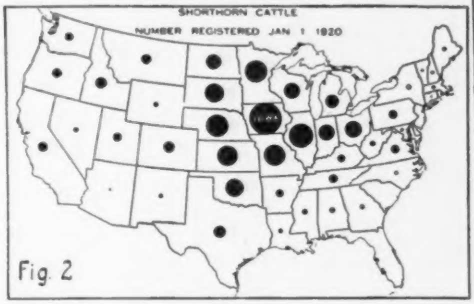


Fig. 2

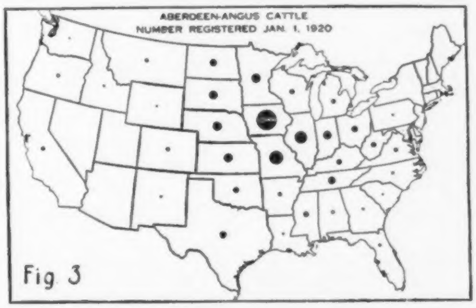


Fig. 3

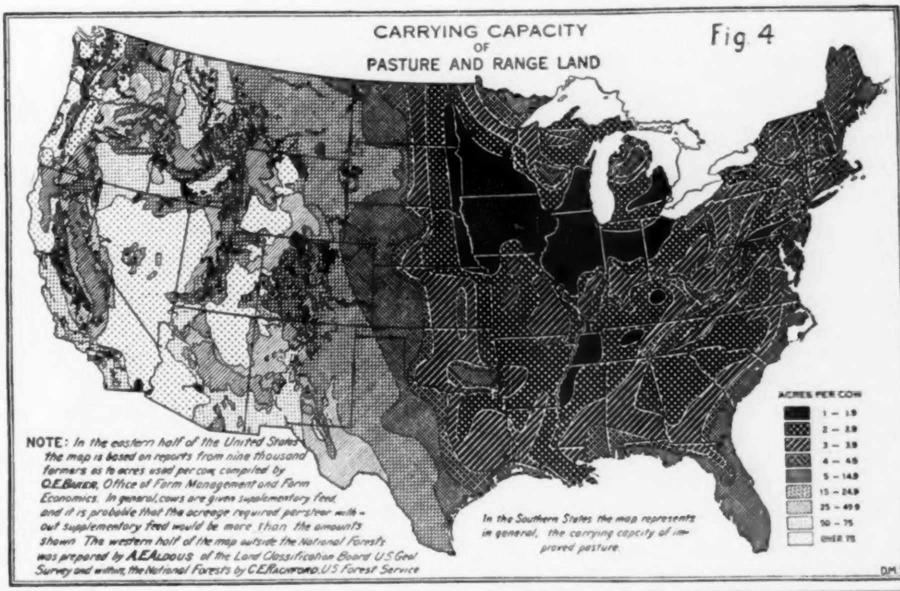
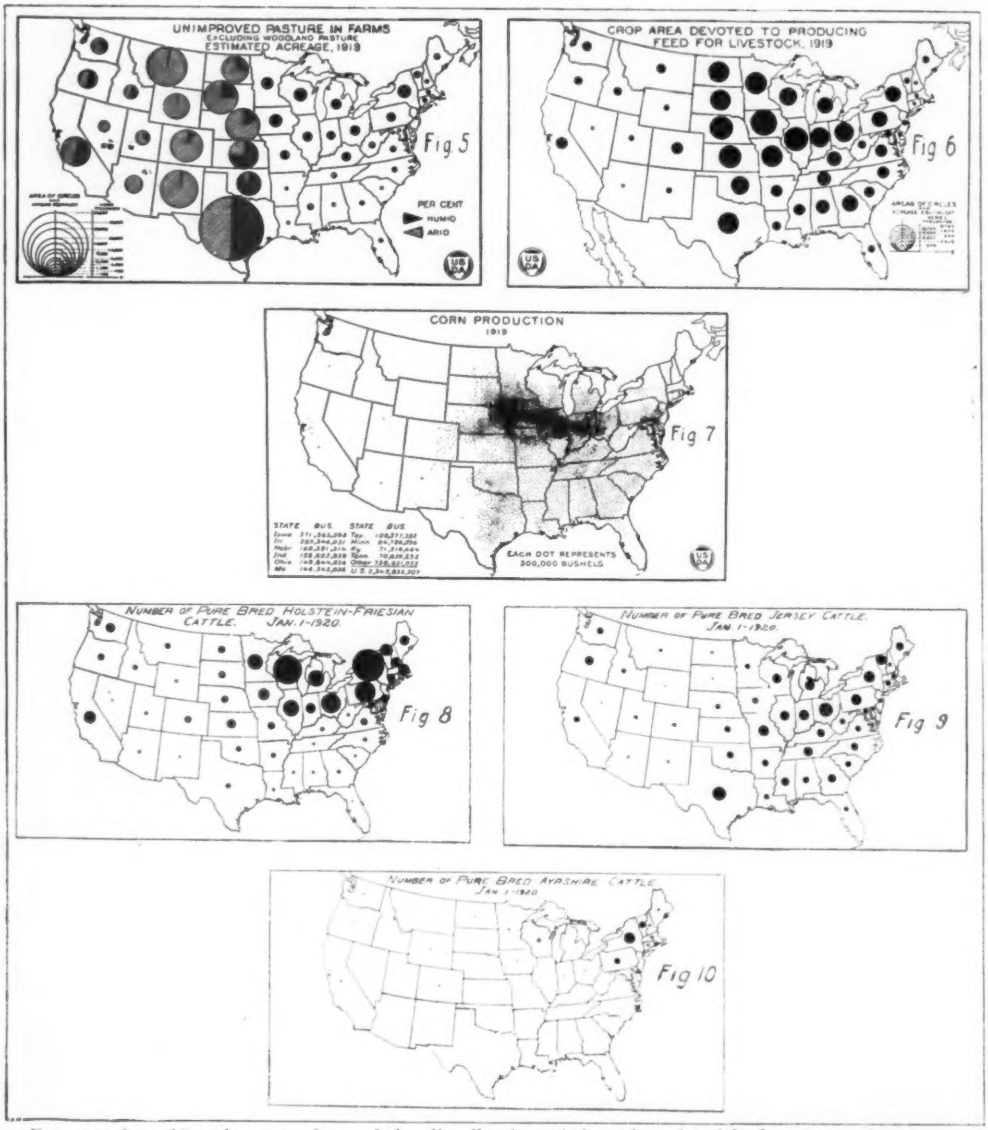


Fig. 4

FIGURES 1 TO 4.—According to the United States Census of 1920 (see Figures 1, 2, and 3) the Shorthorn and Angus breeds of beef cattle are most numerous in the lake states, the Dakotas, and the Corn Belt, while the Hereford breed is most numerous in the western corn belt states, Texas, and the Great Plains region. Figure 4 gives the number of cattle per acre supported by the pasture and range land throughout the United States.

PURE-BRED BEEF BREEDS

The distribution of the Hereford, Shorthorn, and Angus breeds of cattle as described by the United States census in 1920 is illustrated in Figures 1, 2, and 3, and in Table I. According to this census the Shorthorn and Angus breeds are most



FIGURES 5 TO 10.—A comparison of the distribution of these breeds with the crop and pasture regions of the country show that the Shorthorn and Angus cattle are dependent upon abundant pasture and feed, while the Herefords are not so limited by these conditions. The distribution of Holstein, Jersey, and Ayrshire breeds of dairy cattle is shown in Figures 8, 9, and 10.

numerous in the Lake States, the Dakotas, and the Corn Belt. The Hereford breed is most numerous in the western corn-belt states, Texas, and the Great Plains region. In Wyoming, New Mexico, Arizona, and Nevada, the Shorthorn and Angus are almost wanting, whereas the Herefords are quite numerous. In Montana, Colorado, and Utah the Herefords also outnumber the other beef breeds. The claims of the western ranchers that the Hereford is supreme in the Great Plains and semi-arid regions of the West are apparently founded upon more than mere prejudices. The Shorthorn on the other hand holds almost an equal place in the states where feed and pasture are plentiful.

What is the cause of this difference in the distribution of these beef breeds?

TABLE I

DISTRIBUTION OF PURE-BRED BEEF CATTLE IN UNITED STATES IN 1920

State	*Number of Cattle* Hereford	Shorthorn	Angus	*Normal Annual Rainfall*	*Mean Monthly Normal Range in Temperature*	*Normal Annual Relative Humidity*	*Normal Annual Hours of Sunshine*
Ohio	3,229	18,866	2,642	38.3 In.	30° F. to 76° F.	70 per Cent	7.2 Hours
Michigan	1,825	12,779	1,519	31.5 "	24° " 73°	78 "	6.6 "
Indiana	6,615	17,330	4,807	42.7 "	31° " 76°	72 "	7.3 "
Illinois	16,370	42,240	10,106	40.8 "	32° " 78°	72 "	7.6 "
Wisconsin	2,203	17,114	1,539	32.7 "	16° " 70°	75 "	6.7 "
Minnesota	10,787	34,834	5,398	23.9 "	12° " 71°	67 "	6.6 "
Iowa	40,894	75,035	27,457	30.9 "	16° " 74°	74 "	7.5 "
Missouri	32,609	32,826	12,916	36.5 "	27° " 77°	76 "	7.5 "
Oklahoma	12,133	23,236	1,876	29.7 "	32° " 80°	69 "	8.0 "
Kansas	38,695	29,752	4,700	25.3 "	29° " 78°	68 "	8.2 "
Nebraska	27,482	36,197	4,640	27.5 "	21° " 76°	69 "	7.7 "
South Dakota	21,663	26,455	4,788	23.4 "	16° " 72°	60 "	7.7 "
North Dakota	7,089	16,082	3,124	17.6 "	7° " 70°	71 "	7.3 "
Total	221,530	382,746	85,512	Av. 30.8 "	22.5° " 74.7°	70.9 "	7.4 "
Texas	70,021	10,315	2,605	24.7 "	43° " 82°	51 "	8.1 "
New Mexico	14,563	951	111	15.6 "	34° " 72°	45 "	8.8 "
Arizona	5,023	341		8.2 "	51° " 89°	43 "	10.2 "
Nevada	2,442	1,299	15	8.7 "	31° " 73°	48 "	9.1 "
Utah	5,978	4,714	62	16.6 "	24° " 72°	53 "	7.8 "
Colorado	17,270	8,155	615	14.0 "	29° " 72°	53 "	8.2 "
Wyoming	11,845	1,697	115	13.6 "	26° " 67°	52 "	8.0 "
Montana	10,699	6,912	927	15.8 "	19° " 66°	71 "	
Total	137,841	34,384	4,450	Av. 14.7 "	32.1° " 74.1°	52 "	8.6 "
New York	933	888	248	38.6 "	22° " 67°	77 "	5.9 "
Washington	935	4,289	263	37.6 "	40° " 64°	77 "	5.4 "
Oregon	4,182	6,065	776	48.1 "	38° " 67°	74 "	5.7 "
Total	6,050	11,242	1,287	Av. 41.4 "	33.3° " 66°	76 "	5.7 "
Native Home Hereford				27.3 "	38° " 61°	83 "	4.7 "
Native Home Shorthorn				25.1 "	37° " 59°	86 "	3.6 "
Native Home Angus				29.5 "	38° " 58°	78 "	3.8 "

NOTE.—The normal annual rainfall was determined by averaging the yearly rainfall over a large number of years. The normal annual relative humidity and hours of sunshine were determined from the mean monthly values taken over a large number of years.

The first group of states are those that produce a great deal of forage and maintain good pasture. The second group of states are those that compose part of the great plains and most all of the semi-arid regions. The third group of states are those having climates most similar to that of the native home of breeds.

Is it due to the effect of acclimatization to similar climates in their native homes, or to a difference in some other inherent characteristics developed within them?

The climatic diagrams in Figure 11 [3] show very clearly that there is little difference between the climates in the native homes of these breeds.[4] They are all very mild and humid throughout the year. Hence, the Herefords thrive

[3] The climatic measurements graphed in Figures 11 to 22 are the normal mean monthly temperature, relative humidity and hours of sunshine and the normal total monthly rainfall for each month of the year. These measurements are those which were recorded at the meteorological stations located in the regions occupied by the various breeds of cattle. The records of these stations were secured from the following meteorological documents: Climatological data for the United States, Vol. 8, 1921; Report of the Great Britain Meteorological Office, Vol. 5, 1923; and the Netherland Yearbook of Meteorology, Vols. 1892 to 1910.

Comparisons between the climates in these regions were made by the use of the hythergraph (temperature-rainfall), the climograph (temperature-humidity) and the solargraph (temperature-sunshine). The hythergraphs were constructed by plotting to the mean monthly temperatures for each month of the year, the total monthly rainfall and connecting the coördinate points thus determined by straight lines. The climographs and solargraphs were constructed in a similar manner, using instead of the total monthly rainfall, the mean monthly relative humidity and hours of sunshine respectively.

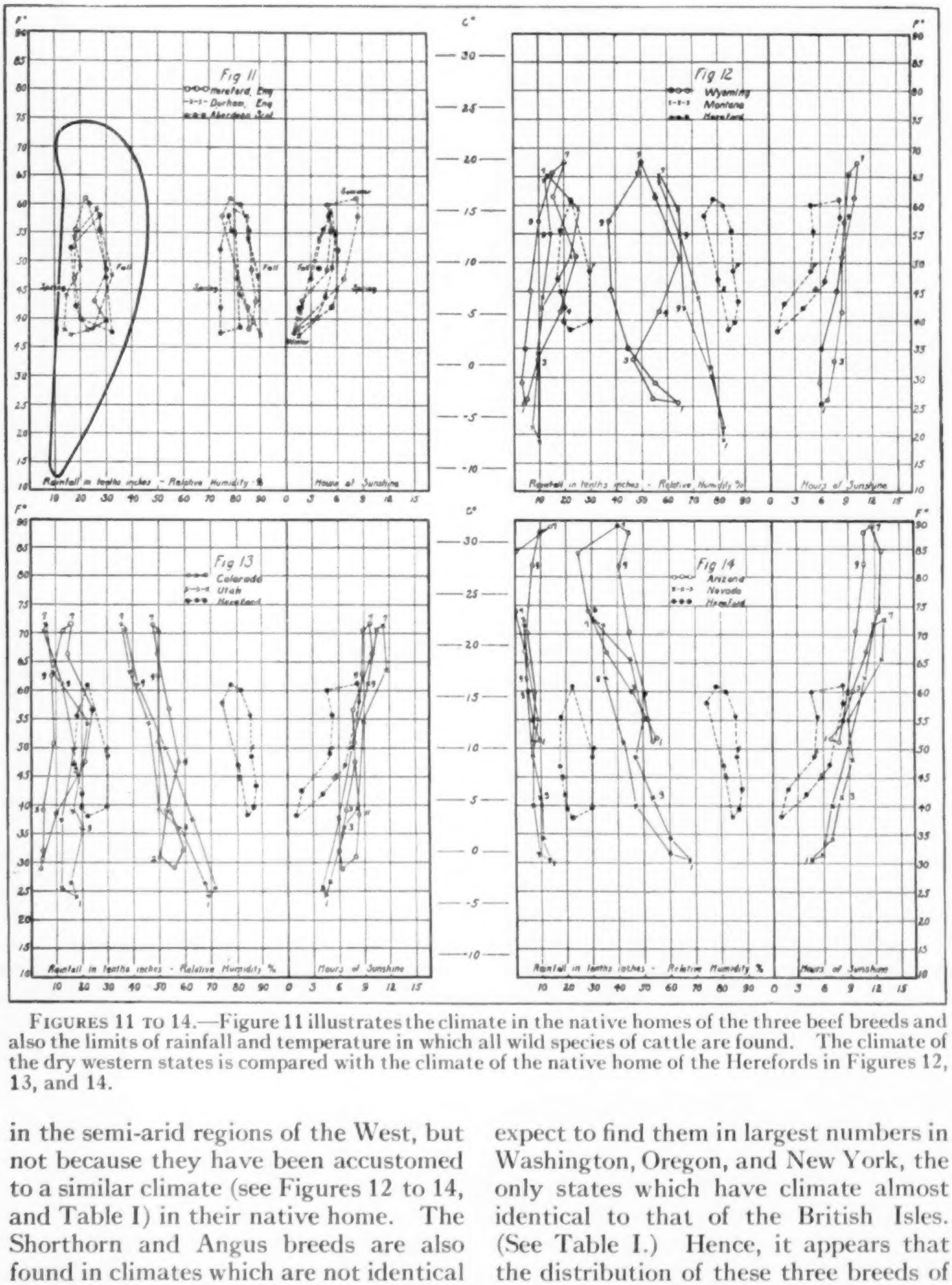
In all of the figures the graphs illustrating the climate in the native homes of the breeds are constructed with dotted lines. The graphs constructed with solid lines illustrate the climate in a particular locality or group of localities in the United States. The climograph is always in the center of the figure and the hythergraph and solargraph to the left and right respectively.

The graphs in Figures 11 and 22 do not always give the coördinate points illustrating the climatic factors for each month in the year, but only the outlying points which determine the limits of climate throughout the year. This method of construction was used in order to eliminate the cumbersome effect of all the monthly coördinate points. The regions in these graphs illustrating the climate during the various seasons of the year are designated at the sides by the words spring, fall, winter, and summer. This same method of construction was also used in the cases where the climatic graphs illustrating the climate in two or more states were combined. The combining of the climatic graphs was done only in cases where they were so nearly alike that it would have been impossible to illustrate each one separately.

The numbers on all of the graphs opposite the coördinate points designate the month of the year represented by the points. The letters "S" and "F" inserted in the graphs illustrating the climate in the native homes of the breeds designate the spring and fall regions.

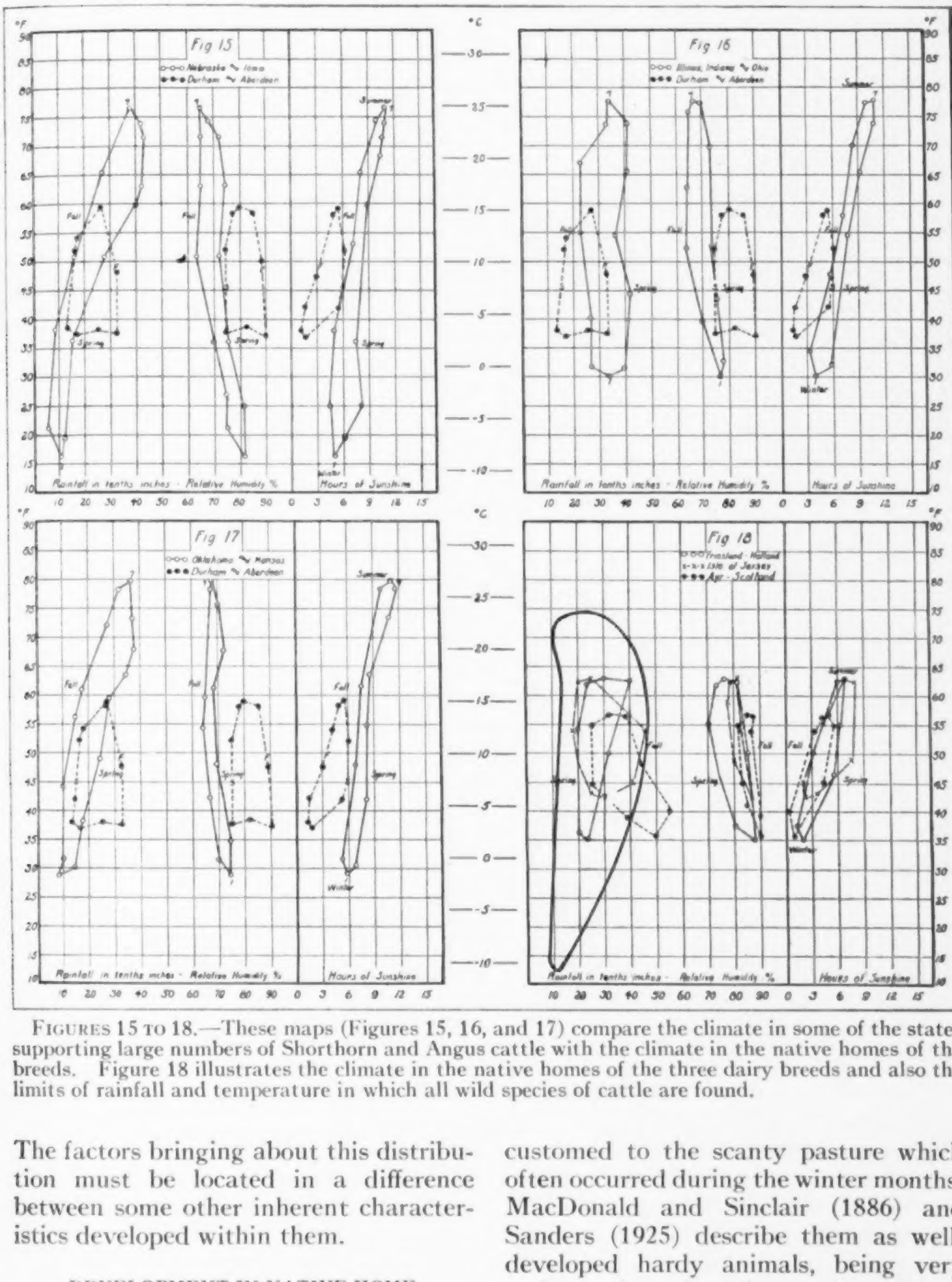
In comparing the climate of one locality to that of another the climatic measurements to be considered in the order of their importance are: range in temperature, range in humidity and range in hours of sunshine. Temperature, humidity and sunshine are more effective than rainfall upon the life activities of warm-blooded animals.

[4] The native homes of the Hereford, Shorthorn and Angus breeds of cattle are: Hereford, England; Durham, England; and Aberdeen, Scotland, respectively.



FIGURES 11 TO 14.—Figure 11 illustrates the climate in the native homes of the three beef breeds and also the limits of rainfall and temperature in which all wild species of cattle are found. The climate of the dry western states is compared with the climate of the native home of the Herefords in Figures 12, 13, and 14.

in the semi-arid regions of the West, but not because they have been accustomed to a similar climate (see Figures 12 to 14, and Table I) in their native home. The Shorthorn and Angus breeds are also found in climates which are not identical to that of their native homes (see Figures 15 to 17, and Table I) but which are not quite as far removed as the dry climate of the West. In fact, if climate was the only limiting factor in the distribution of these cattle in this country, one would expect to find them in largest numbers in Washington, Oregon, and New York, the only states which have climate almost identical to that of the British Isles. (See Table I.) Hence, it appears that the distribution of these three breeds of cattle in the United States cannot be attributed to the effect of acclimatization to similar climates in their native homes. In fact they retain the ability to withstand temperature differences characteristic of the range of the wild species.



FIGURES 15 TO 18.—These maps (Figures 15, 16, and 17) compare the climate in some of the states supporting large numbers of Shorthorn and Angus cattle with the climate in the native homes of the breeds. Figure 18 illustrates the climate in the native homes of the three dairy breeds and also the limits of rainfall and temperature in which all wild species of cattle are found.

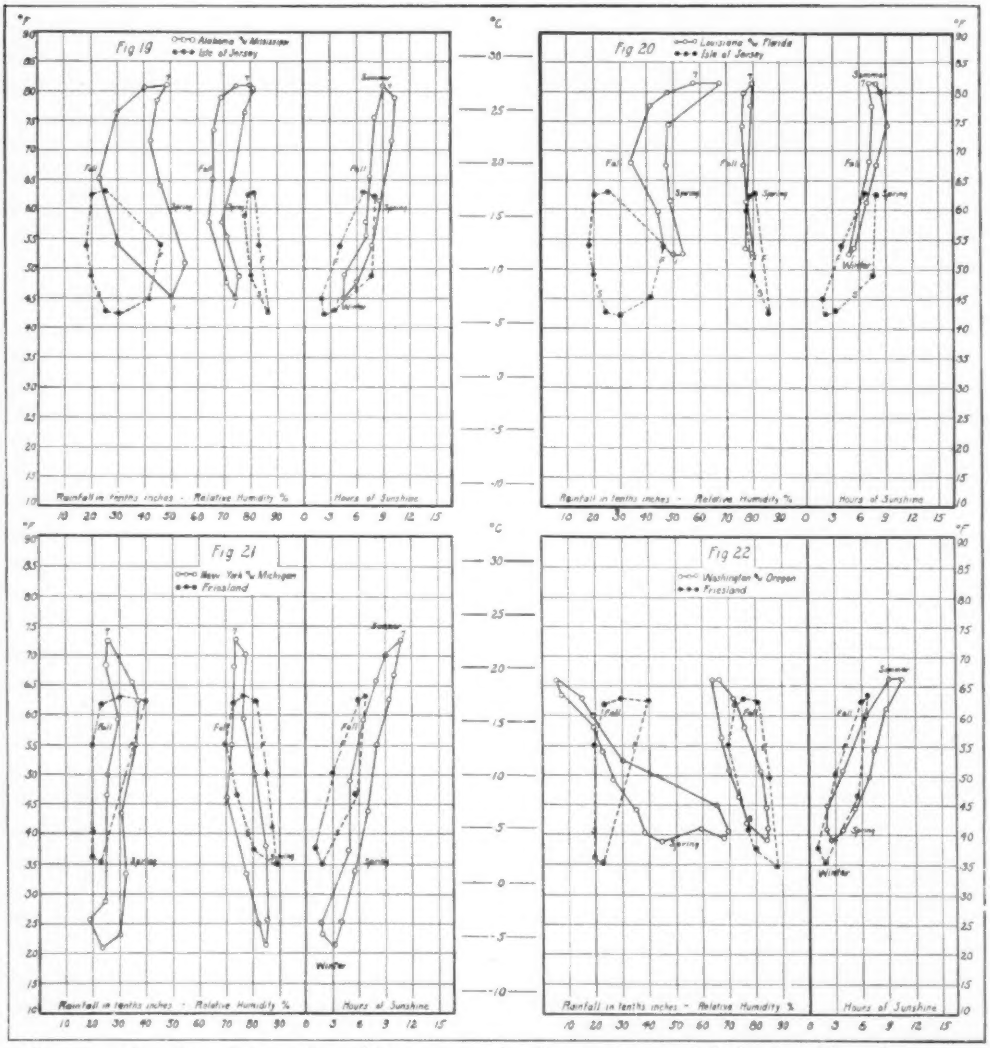
The factors bringing about this distribution must be located in a difference between some other inherent characteristics developed within them.

DEVELOPMENT IN NATIVE HOME

The Herefords in their native home during their early development secured most of their subsistence from the pastures upon which they grazed. They were sheltered and fed very little if any throughout the year and became accustomed to the scanty pasture which often occurred during the winter months. MacDonald and Sinclair (1886) and Sanders (1925) describe them as well-developed hardy animals, being very active and good rustlers and capable of producing a marketable beef carcass on pasture. These characteristics of the early Herefords have been bred and selected throughout the development of the breed.

The Shorthorn and the Angus during their early development enjoyed a some-

what better environment than the Hereford. They also secured a great deal of their subsistence from the pastures upon which they grazed, but were sheltered and fed during the more severe months of the year. In most cases they were refined beef carcass. They were bred for early maturity, large size, and refinement of both beef and bone. They became excellent feeders but did not have the hardiness nor rustling qualities of the Hereford. MacDonald and



FIGURES 19 TO 22.—Figures 19 and 20 compare the climate of some of the hot humid southern states with that of the native home of the Jersey breed, while the climate of some of the northern states is compared with that of the native home of the Holsteins in Figures 21 and 22.

fattened for market in the feed lot and not sold directly from the pasture. Sanders (1925) and Malin (1923) describe the early Shorthorn as being large, well-framed animals capable of handling large amounts of feed and producing a Sinclair (1882) and Sanders (1925) describe the early Angus cattle as rather small but well-developed animals, maturing rapidly and producing a refined beef carcass. Owing to the conditions under which these cattle originated, they

also did not develop the hardiness nor vigor of the Hereford.

DEVELOPMENT IN THE UNITED STATES

In the United States the same characteristics have been bred and selected in these breeds as in their native homes. Forbes (1916) in discussing the differences between Herefords and Shorthorns, makes the following statements: "And these cattle (Herefords) too, are in the open most of their lives. Herefords have always been more of a pasture cattle than any other breed. With Shorthorns it has been a different story, many herds being maintained in bank barns and owing to scant herbage have been housed and grain fed most of the year."

The methods of breeding and selection which have been practiced in the development of these breeds both in their native homes and in the United States have produced in the Hereford a hardy active animal capable of living on scanty pastures and weathering adverse environments. In the Shorthorn they have produced a large, rapid maturing animal with excellent feed lot tendencies, but lacking the hardiness and vigor of the Hereford. The Angus is quite similar to the Shorthorn in this respect and both breeds are dependent upon good pasture and plenty of feed. Wilcox (1922) in discussing the differences between these breeds, makes the following statements: "At the present time the Herefords have the advantage in the range country where feed is scarce. They, unlike the Shorthorns, are not big feeders. Where the range men feed their stock the Shorthorn does fairly well. . . . Most Hereford breeders claim that the Hereford has more constitution and gets a better calf crop. If Hereford sires are turned out with other sires most of the calves will be Herefords. This has been proven over and over again."

A comparison of the distribution of these breeds, Figures 1, 2, and 3, with the crop and pasture regions of the country, Figures 4, 5, 6, and 7, shows that the dependence of the Shorthorn and Angus upon good pasture and plenty of feed is more than a mere assumption. Where the production of forage and good pasture stops, the Shorthorn and Angus stop, but the Hereford continues. The presence of abundant pasture and feed practically determines the distribution of the Shorthorn and Angus cattle, owing to the fact that they have had developed within them heritable characters which make them dependent upon such conditions. The Herefords, on the other hand, are not limited by these conditions and are more cosmopolitan in their distribution, owing to their inherent ability to maintain themselves on scanty pastures.

METABOLISTIC EXPLANATION OF DIFFERENCE BETWEEN SHORTHORNS AND HEREFORDS

The supremacy of the Herefords on the scanty pastures of the semi-arid West has been attributed to their better constitution, vigor and rustling qualities. These characteristics are no doubt of advantage to the Hereford but it seems to the author that their greatest advantage lies in their apparently lower rate of metabolism.

Herefords have always been selected for their ability to thrive upon pasture and hence have developed a physiological system which functions normally upon a comparatively low plane of nutrition. The Shorthorns on the other hand have always been bred for their ability to utilize large quantities of feed and to produce a well-filled beef carcass in the feed lot. Hence they have developed a physiological system which functions normally upon a comparatively high plane of nutrition. Put the two breeds together on the scanty pastures of the semi-arid West and which one is the more likely to survive? The Herefords are by far the better fitted. The low plane of nutrition provided by the dry scanty pasture greatly weakens the vitality [5] of the Shorthorns and it is not

[5] Trowbridge *et al.* (1918) have shown that a low plane of nutrition reduces the coefficient of digestibility of the feed consumed.

TABLE II

DISTRIBUTION OF PURE-BRED HOLSTEIN AND JERSEY CATTLE IN UNITED STATES IN 1920

State	*Human Population*	*Number of Cattle* Holstein	Jersey	*Normal Annual Rainfall*	*Mean Monthly Normal Range in Temperature*	*Normal Annual Relative Humidity*	*Normal Annual Hours of Sunshine*
NORTH CENTRAL EAST							
Maine	768,014	7,206	4,999	44.4 In.	18° F. to 70° F.	76 Per Cent	6.7 Hours
Massachusetts	3,852,356	10,006	2,904	43.3 "	24° " 71°	76 "	6.7 "
Connecticut	1,380,631	4,859	2,257	45.3 "	26° " 72°	76 "	6.7 "
Rhode Island	604,397	542	351	46.1 "	27° " 73°	76 "	6.7 "
New Hampshire	443,083	6,695	1,348	40.1 "	21° " 69°	76 "	6.7 "
Vermont	352,428	13,413	8,446	37.4 "	15° " 68°	76 "	6.7 "
New York	10,385,227	114,662	13,411	J. 46.7 "	28° " 74°	81 "	5.6 "
				H. 38.6 "	22° " 67°	77 "	5.9 "
Michigan	3,668,412	32,702	8,296	31.1 "	22° " 71°	78 "	6.6 "
Wisconsin	2,632,067	80,845	7,791	32.7 "	16° " 70°	75 "	6.7 "
Minnesota	2,387,125	22,830	2,508	23.9 "	12° " 71°	67 "	6.6 "
Iowa	2,404,021	10,916	3,629	30.9 "	16° " 74°	74 "	7.5 "
Missouri	3,404,055	5,569	10,708	J. 44.6 "	31° " 76°	76 "	7.5 "
				H. 36.5 "	27° " 77°	76 "	7.5 "
Illinois	6,485,280	25,124	7,317	J. 40.8 "	32° " 78°	72 "	7.6 "
				H. 31.2 "	22° " 74°	77 "	7.6 "
Indiana	2,930,390	8,477	9,921	J. 42.7 "	31° " 76°	72 "	7.3 "
				H. 32.6 "	23° " 73°	74 "	6.8 "
Ohio	5,759,394	38,327	23,842	J. 38.3 "	30° " 76°	70 "	7.2 "
				H. 37.0 "	26° " 72°	73 "	6.2 "
Pennsylvania	8,720,017	48,652	11,036	J. 40.3 "	30° " 73°	71 "	6.2 "
				H. 34.6 "	24° " 71°	70 "	6.9 "
New Jersey	3,155,900	7,810	1,368	47.2 "	29° " 75°	73 "	7.2 "
Delaware	223,003	1,245	172	43.7 "	34° " 77°	69 "	7.1 "
Maryland	1,449,661	4,073	2,323	42.9 "	31° " 75°	69 "	7.1 "
Total	61,005,461	443,953	122,627	Av. J. 38.2 "	25° F " 73° F	74 "	6.9 "
				Av. H. 37.9 "	23° F " 72° F	74 "	6.8 "
CENTRAL WEST							
Kansas	1,769,257	10,408	4,784	25.3 "	29° " 78°	68 "	8.2 "
Colorado	939,629	4,057	1,605	14.0 "	29° " 72°	53 "	8.2 "
Nebraska	1,296,372	5,368	1,275	27.5 "	21° " 76°	68 "	7.7 "
South Dakota	636,547	4,027	312	23.4 "	16° " 72°	60 "	7.8 "
North Dakota	646,872	2,937	481	17.6 "	7° " 70°	71 "	7.3 "
Total	5,288,677	26,797	8,457	Av. 21.5 "	20° F " 74° F	64 "	7.8 "
PACIFIC COAST							
Washington	1,356,621	7,673	3,402	37.6 "	40° " 64°	77 "	5.4 "
Oregon	783,389	3,624	7,771	48.1 "	38° " 67°	74 "	5.7 "
California	3,426,861	12,189	3,832	S. 15.6 "	54° " 72°	70 "	8.7 "
				N. 14.0 "	47° " 73°	64 "	9.3 "
Total	5,566,871	23,486	15,005	Av. 28.8 "	45° F. " 69° F.	71 "	7.3 "
SOUTH CENTRAL EAST							
Virginia	2,309,187	4,160	3,223	41.6 "	38° " 78°	70 "	7.4 "
West Virginia	1,463,701	1,134	2,546	45.9 "	38° " 77°	78 "	5.7 "
Kentucky	2,416,630	2,046	6,421	48.3 "	37° " 79°	79 "	6.6 "
North Carolina	2,559,123	1,613	4,978	49.3 "	40° " 79°	71 "	7.6 "
Tennessee	2,337,885	1,383	9,424	48.5 "	38° " 80°	71 "	7.3 "
Arkansas	1,752,204	2,001	4,627	49.9 "	41° " 81°	72 "	7.6 "
South Carolina	1,683,724	1,008	3,389	46.1 "	45° " 81°	71 "	7.3 "
Georgia	2,895,832	1,700	6,224	45.9 "	47° " 81°	73 "	7.5 "
Alabama	2,348,174	1,142	4,608	51.2 "	48° " 81°	71 "	7.6 "
Mississippi	1,790,618	1,331	6,571	51.8 "	45° " 81°	74 "	7.8 "
Louisiana	1,798,509	1,009	2,201	58.6 "	52° " 82°	78 "	6.9 "
Florida	968,470	337	2,380	53.0 "	59° " 81°	78 "	7.2 "
Texas	4,663,228	2,973	18,718	S. 26.9 "	51° " 83°	68 "	7.6 "
				N. 37.6 "	45° " 84°	51 "	8.1 "
Oklahoma	2,028,283	3,741	5,104	29.7 "	32° " 80°	69 "	8.0 "
Total	31,015,568	25,578	80,414	Av. 45.6 "	44° F " 81° F	72 "	7.4 "
Native Home — Holstein				29.4 "	35° " 63°	80 "	4.0 "
Native Home — Ayrshire				44.9 "	36° " 57°	86 "	3.0 "
Native Home — Jersey				33.5 "	43° " 63°	82 "	5.9 "

NOTE.—The letters J. and H. when found in the rainfall column indicate Jersey and Holstein regions in the state. The letters N. and S. in same column indicate north and south regions of state.

The relative humidity and hours of sunshine were determined for the whole New England section.

See Table I for explanation of column headings.

long before they drop by the wayside, whereas the Herefords, being better fitted for such an environment are only slightly affected. The Angus cattle, being similar to the Herefords, no doubt share the same fate under like conditions.[6]

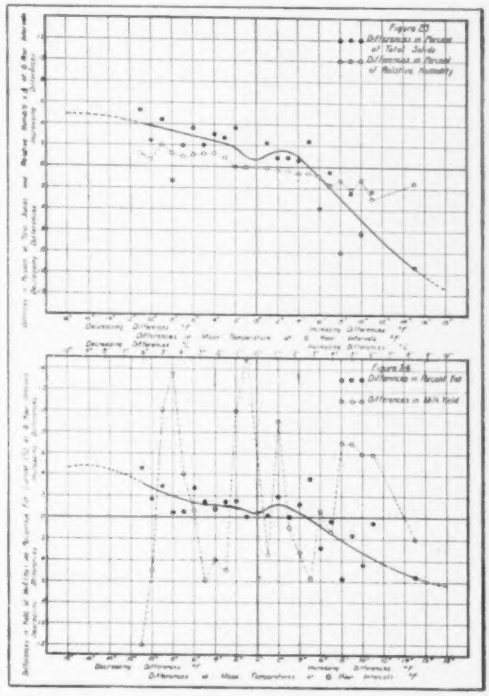
Where the Shorthorns are fed upon pasture there is a different story to tell, for here they are provided with sufficient food to function normally and there is very little evidence of weakness in vitality and constitution among the cattle.

PURE-BRED DAIRY BREEDS

The distribution of the Holstein and Jersey breeds of dairy cattle as described by the United States census in 1920 is illustrated in Figures 8, 9, and 10, and Table II. According to this census the Holstein breed is most numerous in those states east of the Mississippi River and north of Kentucky and the Virginias. Minnesota, Iowa, Kansas, and the western coast states also report quite large numbers of Holsteins. The southern states, including Texas and Oklahoma, report very few Holsteins. The Jersey breed on the other hand is numerous throughout the southern states and also in many of the states dominated by the Holsteins.

Breeders of dairy cattle in the South have long recognized the superior ability of the Jerseys to withstand the hot, humid climate of their states. In the South the Jerseys practically live on pasture all year round and are only slightly affected by the intense heat and humidity. The Holsteins on the other hand cannot withstand the heat upon pasture and suffer greatly during the hottest months of the year. Here again, is this difference in the distribution of the Holsteins and Jerseys due to the effect of acclimatization to similar climates in their native homes or to a difference in some other inherent characteristics developed within them.

[6] Angus bulls are subject to an infection of their urogenital organs when put upon the western pastures. This handicap also adds to the unpopularity of this breed in the West.



FIGURES 23 AND 24.—Variations in the composition of the milk produced from one milking to another due to increasing and decreasing environmental humidity and temperature.

The climatic diagrams in Figure 18 show that Holland is slightly cooler in winter than the Island of Jersey but just as warm in summer.[7] The rainfall and sunshine are a little greater on the Island but the relative humidity is practically the same. There is certainly not enough difference between these climates to acclimate the Jersey more than the Holstein to the intense heat of the South. (See Figures 19 and 20 and Table II.) The majority of the Holsteins are also found in states having climates which are not identical to that of their native home, but which do not become extremely warm in summer.[8] (See Figure 21

[7] The native homes of the Holstein, Jersey, Guernsey, and Ayrshire breeds of cattle are: Friesland, Holland; Isle of Jersey; Isle of Guernsey; and Ayr, Scotland, respectively.

[8] In the southern states, with the exception of the Virginias, and Kentucky, the mean monthly temperature during the summer hovers around 80° F. and the mean monthly relative humidity averages close to 75 per cent. This hot, humid climate practically eliminates the Holstein from the South. It is the combined effect of the high

FIGURE 25.—Hereford cows at Zeals Farm, Wiltshire. The native home of this breed is in Hereford County, England. (Taken from "History of Hereford Cattle," MacDonald and Sinclair, Vinton and Company, 1909.)

and Table II.) This difference in the distribution of these breeds can certainly not be attributed to the effect of acclimatization to similar climates in their native homes. The Jersey has been acclimated no more to the heat of the South than has the Holstein, nor has the Holstein been acclimated any more to the cold of the North than has the Jersey. The Holstein and Jersey thrive very well in the North but the Jersey, alone, thrives well in the South. The cause of this peculiarity in the distribution of these breeds must be looked for in a difference in some other inherent characteristics developed within them.

Before going into a discussion of the development of these breeds it will be necessary to consider the claims of the economists in regard to the effect of the centers of population upon the distribution of the dairy breeds.

THE EFFECT OF CENTERS OF POPULATION UPON THE DISTRIBUTION OF THE DAIRY BREEDS

The greater number of dairy cattle in the eastern half of the United States, as compared to the western half, is no doubt due in part to the greater population in the former. However, the distribution of Holsteins and Jerseys in the northern and southern states is influenced very little if any by centers of population. The population of the southern states is one-half as great as the population of the states east of the Mississippi River and north of the Virginias and Kentucky. (See Table II.) If centers of population directly affected the distribution of Holsteins and Jerseys in these two regions there would be approximately half as many Holsteins and half as many Jerseys in one as in the other. There are actually one-eighteenth as many Holsteins and two-thirds as many Jerseys in the southern states as in the northern states, thus showing that this difference in the distribution of these breeds cannot be attributed to a difference in the centers of population.

DEVELOPMENT WITHIN NATIVE HOME

The Jerseys in their native home live mostly upon pasture and are sheltered and fed only during the most severe weather in winter. They have been bred and selected for refinement of dairy type, strong vitality and ability to thrive and produce upon pasture. They are small refined animals strictly dairy in type and

temperature and humidity which is so detrimental to the Holstein as will be shown in the discussion concerned with the difference in the metabolism of the two breeds. In the warm but drier western states the Holsteins are doing fairly well.

FIGURE 26.—Herefords in the Arid West. (Taken from "Cattle of the World," A. H. Sanders, Washington, D. C.)

are very active and good grazers. They, like the Herefords, are able to thrive on scanty pastures and endure extreme of climate and poor nourishment.

The Holsteins in their native home have originated under conditions very unlike those on the Island of Jersey. The cows are pastured during the summer months and milked upon the pastures so as not to fatigue them by walking to the barn. They are also blanketed at the least provocation of a storm. About the first of October they are put in a barn kept unthinkably clean, and remain indoors until about the first of May. They have been bred for large size and ability to consume large quantities of feed and produce great quantities of milk. They are very large, well-framed animals, strong in constitution,

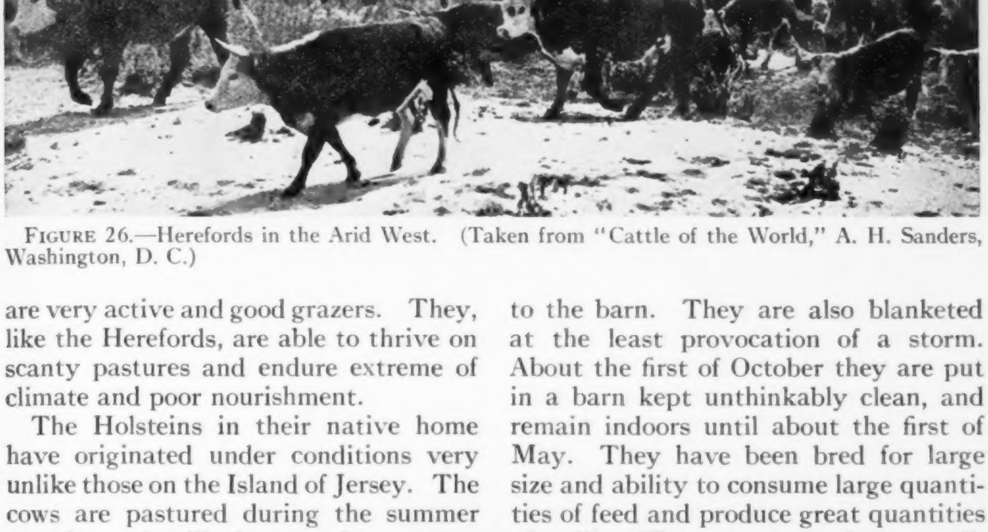


FIGURE 27.—Herds of Hereford and Shorthorn descendants in the Tropics. (Taken from "Cattle of the World," A. H. Sanders, Washington, D. C.)

FIGURE 28.—The "Steading" at Uppermill. The native home of the Shorthorns is in Durham County, England. (Taken from "Shorthorn Cattle," A. H. Sanders, *Breeders Gazette.*)

big feeders and excellent milk producers. They are, however, very poor grazers, owing to the fact that they are not capable of gathering sufficient food from ordinary pastures to supply their enormous demands.

DEVELOPMENT IN UNITED STATES

In the United States the Holsteins and Jerseys have been bred along practically the same lines as in their native homes. These methods of breeding have produced two distinct types of animals differing greatly in size, feed consumption, and ability to produce milk. The Holstein is to a great extent dependent upon an abundance of feed for normal functioning whereas the Jersey is much less dependent upon such conditions. The amount of feed available, however, is not the factor which eliminates the Holstein from the south, for there is plenty of feed and pasture produced in the southern states. (See Figures 4, 5, 6, and 7.)

METABOLISTIC EXPLANATION OF DIFFERENCE BETWEEN HOLSTEINS AND JERSEYS

The results from animal experimentation, Lusk (1917), have shown that the radiation of heat from the body is a very important factor in the metabolism of warm-blooded animals. The amount of heat liberated from the body of a warm-blooded animal varies directly with the amount of food consumed and indirectly with the temperature and humidity or the surrounding air. High temperature

FIGURE 29.—A herd of Shorthorns grazing in Iowa, characteristic of the Corn Belt. (Taken from "The Shorthorn in America," July, 1916.)

FIGURE 30.—A herd of Holsteins grazing in the district of Northern California. In the background one sees the silos that distinguish the dairy farms. (Taken from "Holstein Fresian World," Vol. 17, 1920.)

and high humidity greatly retard the radiation of heat from the body, Rubner (1902), and hence greatly handicap an animal functioning on a high plane of nutrition. Another important factor to consider in the radiation of heat from the animal body is that the amount of heat lost by radiation per unit of body weight is greater the smaller the animal.

The Holsteins being bigger feeders than the Jerseys normally function on a higher plane of nutrition and hence are more sensitive to high temperatures and high humidities. They are also not as well equipped for the radiation of heat from their bodies as are the Jerseys owing to their greater size. The reason for their inability to withstand the hot, moist climate of the southern states can readily be attributed to their large size and normally high plane of nutrition. The Jersey on the other hand is better equipped to withstand the heat and humidity owing to its smaller size and normally lower plane of nutrition. A mean monthly temperature of 78° to 82° F. during June, July, and August combined with a mean monthly relative humidity of 75 per cent to 80 per cent practically eliminates the Holsteins. No such temperatures are experienced during June, July, and August in the states where the majority of the Holsteins are found. Even in the northern states where the Holsteins and Jerseys occupy different regions of the state, the Holsteins are always found in the cooler sections. (See Table II.)

In some of the warm but drier western states the Holsteins seem to do fairly well. This is no doubt due to the low humidity, which of course decreases the effect of the high temperature upon the radiation of heat from the body. The nights of the southern western states are also generally a great deal cooler than the nights in the southern eastern states.

The presence of high temperatures combined with high humidity during the summer months practically deter-

mines the distribution of the Holstein and Jersey breeds of cattle in this country. This is due to the fact that they have had developed within them peculiar, inherent characteristics which enables the Jersey to withstand the heat and humidity of the southeastern states and limits the Holstein to the cool or warm and dry regions of the country.

THE EFFECT OF CLIMATE ON MILK SECRETION IN DAIRY COWS

Hills (1892) found that the percentage of fat in the milk from thirty herds of cows varied indirectly with the temperature from week to week during the months of May to September inclusive. Eckles (1909), Ragsdale and Turner (1922) and others have demonstrated that the percentage of fat in cows' milk varies with the season of the year regardless of the stage of lactation of the cows. It is highest in winter and lowest in summer. This seasonal difference in the percentage of fat in the milk is due in part to the accompanying seasonal change in temperature. Ragsdale and Brody (1922) kept daily records on ten cows under ordinary herd conditions and found that on the average the percentage of fat in the milk produced increased .2 of 1 per cent for every decrease of 10° F. between the temperatures of 30° to 70° F. These records were recorded against outside temperatures, and during bad days the cows were kept in the barn. Hence the data are not sufficiently accurate. Hayes (1926) conducted another experiment similar to the above, but recorded the temperature both when the cows were in the barn and when they were outside of the barn. The results from this experiment, Table III, show that there was a gradual increase in the percentage of fat in the milk with decreasing temperature, but not as great as that found by Ragsdale and Brody. Hayes also conducted an experiment wherein two Jersey cows were kept in rooms of constant temperature for varying lengths of time, and their daily milk productions recorded. No attempt, however, was made to control the humidity in these rooms. The results from this experiment are reported in Table IV. Hayes' conclusions in regard to these results are as follows: "From 72.5° to 27° F. there was a total increase of .863 per cent of fat or an average increase of .189 per cent fat for each 10° lowering of the temperature. . . . It would seem that there is a range of temperature between 70° and 90° F. within which the lowest fat testing milk is produced."

TABLE III

Number of Days	*Average Temperature for Group*	*Average Per Cent of Fat*
5	86.5	3.171
50	79.2	3.250
69	69.6	3.389
48	60.5	3.481
38	49.7	3.505
35	40.1	3.463
9	31.0	3.465
2	24.5	3.600

NOTE.—See note in Table IV.

TABLE IV

Trial	*Total Number of Days*	*Average Temperature for Entire Trial*	*Average Pounds Milk Per Day*	*Average Per Cent Fat for Entire Trial*
I	8	92.7	20.8	5.388
VI	4	80.0	21.6	5.227
II	6	72.5	20.5	5.149
V	4	60.9	21.0	5.424
IV	5	52.3	21.3	5.646
III	6½	39.9	20.2	6.099
VII	5	27.0	18.4	6.012

NOTE.—Tables 3 and 4. The effect of environmental temperature on the quantity and quality of the milk produced. After Hayes (1926).

Up to the present time, all the work bearing upon the relation between the rate of milk secretion and environmental temperature, has been based upon daily averages of both temperature and production and no attempt has been made to measure the effect of changes in temperature upon the rate of milk secretion from one milking to another. The daily march of temperature and humidity rises and falls during the day and night and no doubt has an opposite effect upon the quality of the milk produced at the corresponding milkings.

FIGURE 31.—Holsteins in Holland. The windmill and the black-and-white cattle are typical of the Dutch country side. (Taken from "Cattle of the World," A. H. Sanders, Washington, D. C.)

THE EFFECT OF ENVIRONMENTAL TEMPERATURE AND HUMIDITY UPON THE RATE OF MILK SECRETION BETWEEN MILKINGS

Huntington (1924) compared differences in the amount of work performed by factory men from day to day to differences in the corresponding mean daily temperatures and found that the amount of work performed tended to vary inversely with the environmental temperature. The author compared differences in the quantity and quality of the milk produced at six-hour intervals to differences in the corresponding mean "six-hour interval" temperatures and found that a similar relation existed between the quality, but not the quantity of the milk produced, and the environmental temperature.[9] The data illustrating this relation are reported graphically in Figures 23 and 24, and consisted of eighty-five observations on seven pure-bred cows milked at six-hour intervals. The temperature during the time these observations were made ranged from 50° to 89° F.

From the graphs in Figure 24 it will be seen that the quantity of the milk produced at six-hour intervals is not influenced in any definite manner by environmental temperature. The results of Hayes (1926) reported in Table IV also show that the quantity of the milk produced is not influenced by environmental temperature over short periods of time. Over extended periods of time, however, continued high temperature tends to bring about a decrease in the quantity of the milk produced as has been shown by Wylie (1925) with respect to the seasonal effect upon milk production. The percentage of total solids and the percentage of fat on the other hand, tend to vary inversely with the temperature.[10] Increasing temperature from milking to milking tends to bring about a decrease in the percentages of total solids and fat in the milk produced. Decreasing temperature from milking to milking tends to bring about an increase in the percentages of total solids and fat in the milk produced. Increasing temperature, however, has a more marked effect upon the percentages of total solids and fat than decreasing temperature. Hence it is well seen that in measuring the effect of environmental temperature upon the quality of the milk produced, one cannot

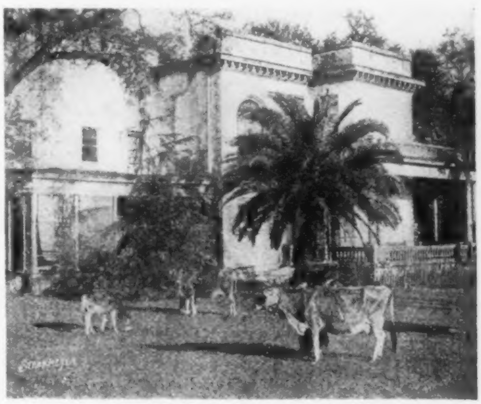


FIGURE 32.—The Jersey breed is usually found grazing in the pastures of Florida, wherever dairying is possible. (Taken from "Jersey Bulletin," Vol. 41, 1922.)

[9] The intervals in which the temperature increased or decreased did not consistently fall on the same milkings.

[10] The percentage of total solids was determined by the gravimetric method and the percentage of fat by the Roese-Gottlieb method.

FIGURE 33.—At home on the Island of Jersey. (Taken from "Jersey Bulletin," Vol. 38, 1919.)

assume that a 10° drop in temperature from 70° to 60° F. will have the same effect as a 10° increase from 60° to 70° F., or, in other words, that the effect of environmental temperature is uniform regardless of whether the temperature is increasing or decreasing.

The average differences in relative humidity as graphed in Figure 23 tend to vary inversely with the temperature, but only to a slight degree. In the range of increasing temperature from 6° to 15° F. there also seems to be a slight inverse relation between the humidity and percentage of total solids. Owing to the fact that the percentage of fat varies directly with the percentage of total solids, a similar relation also exists between the humidity and percentage of fat in the increasing range of temperature from 6° to 15°. In the decreasing range of temperature the humidity stands at about the same level throughout the range and, as will be shown later on, has a tendency to exaggerate the effect of the temperature.

EXPLANATIONS OF EFFECT OF ENVIRONMENTAL TEMPERATURE ON THE RATE OF MILK SECRETION

Hayes (1926) in attempting an explanation of the effect of environmental temperature on the rate of milk secretion brings forth two hypotheses. The first, and the one thought by Hayes to be most logical, is that the blood becomes more concentrated at low temperatures and hence contains a larger percentage of fat, which results in an increased percentage of fat in the milk,[11] the reverse of course being true at high temperatures. Hayes cites the work of Gage and Fish (1924), who demonstrate that there is no diffusion of the fat in the blood into the milk. Meigs (1922) in reviewing the work on this subject claims that up to the present time there is no evidence of any diffusion of blood fat into the milk. The fat in the milk is of an altogether different composition than the fat in the blood. Hence, if no diffusion takes place, then the concentration of the fat in the blood could have no influence upon the concentration of the fat in the milk.

Since Meigs (1922) has shown that milk fat, protein, and carbohydrate are

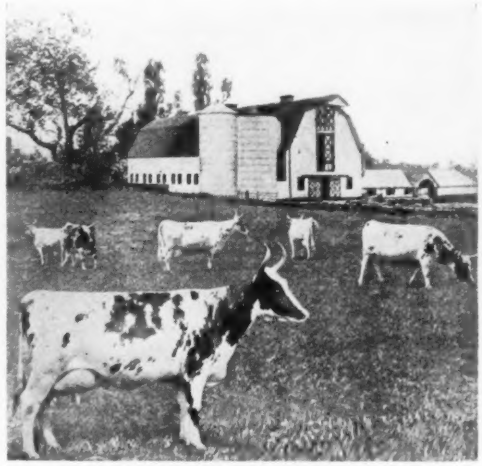


FIGURE 34.—Ayrshire cows grazing on the green pastures of New York State. (Taken from "The Ayrshire Digest," 1924.)

[11] Hayes cites the work of Barbour and Lusk who claim that the hemoglobin, the red blood cell count, and the viscosity of the blood, increase at low temperatures. This may be the condition at low temperatures but it does not logically follow that the nutrients in the blood likewise increase in concentration. Furthermore, the relation between blood viscosity and temperature is not a general conception among physiologists.

synthetic products of the mammary gland, it stands to reason that their concentration in the milk is more dependent upon the activity of the gland than upon the concentration of their precursors in the blood. Meigs also cites evidence which indicates that the yield of the mammary gland is nearly proportional to the rate of blood flow through it. The activity of the mammary gland and the rate of blood flow throughout the body tend to vary directly with the rate of metabolism of the body and any factors influencing the latter would also tend to influence the former. This is essentially the same relation stated by Hayes in his second hypothesis, but he apparently failed to notice its significance.

Rubner (1902) has demonstrated very clearly that the rate of metabolism of the body tends to vary inversely with the environmental temperature and humidity.[12] Hence, since the activity of the mammary gland is closely associated with the rate of metabolism it is not surprising that an inverse relation also exists between the rate of milk secretion and the environmental temperature. This relation, however, would not continue at very high or very low temperatures owing to the fact that at such temperatures the temperature regulating mechanism of the body would be broken down and the whole physiological system disturbed.

FIGURE 35.—A herd of Ayrshire cows on a typical Scotch farm. (Taken from "The Ayrshire Digest," 1926.)

THE PHYSIOLOGICAL REACTIONS OF DAIRY CATTLE TO CLIMATE

The milk flow of dairy cows, as has been shown, is very sensitive to changes in environmental temperature and humidity and hence provides a reasonably accurate measure of their physiological reactions to climate. The degree of this sensitiveness is, however, not the same for all cows, but varies directly with the level of production upon which the cows are producing.[13]

It has been shown that the Jersey and Holstein breeds of dairy cattle are located in the United States in regions which

[12] The effect of humidity upon the rate of metabolism changes from low to high temperatures. At high temperatures it tends to suppress the rate of metabolism and at low temperatures it tends to increase the rate of metabolism.

[13] See metabolistic explanation on page 478.

have climate unlike that of their native homes. Hence some knowledge of their physiological reactions to these strange climates may be secured by a study of their milk productions in the corresponding regions.[14] Accordingly the production records of all pure-bred Jersey cows producing 600 pounds or more of butterfat and all pure-bred Holstein cows producing 650 pounds or more of butterfat were listed for each state.[15] The states having thirty or more such records for either Holstein or Jersey cows are reported in Tables V and VI respectively. These production records were also averaged by states on the F. C. M. basis and likewise reported in Tables V and VI.

TABLE V

PURE-BRED HOLSTEIN COWS IN THE UNITED STATES PRODUCING 650 POUNDS OR MORE OF BUTTERFAT

States Having 30 or More Cows with Records of 650 Lbs. or Better	*Number of Records of 650 Lbs. or Better*	*Number of P. B. Animals in 1920*	*States Having 30 or More Cows with Records of 650 Lbs. or Better*	*Average F. C. M. Production of Records of 650 Lbs. or Better*	*Mean Monthly Range in Temperature and Mean Annual Relative Humidity*	
Wisconsin	485	80,845	Washington	20,831 Pounds	40° F. to 64° F.	77%
Minnesota	402	22,830	California	20,807 "	50° " 72°	68%
California	357	12,189	New York	20,506 "	22° " 67°	77%
Ohio	344	38,327	Oregon	20,136 "	38° " 67°	74%
New York	239	114,662	New Jersey	20,126 "	29° " 75°	73%
Washington	190	7,673	Minnesota	19,888 "	12° " 71°	67%
Michigan	172	32,702	Michigan	19,862 "	22° " 71°	78%
Iowa	161	10,916	Illinois	19,747 "	22° " 74°	77%
Massachusetts	147	10,006	Ohio	19,720 "	26° " 72°	73%
Illinois	126	25,124	Kansas	19,678 "	29° " 78°	68%
Pennsylvania	109	48,652	Massachusetts	19,657 "	24° " 71°	76%
Nebraska	93	5,368	Pennsylvania	19,533 "	24° " 71°	70%
Oregon	63	2,624	Nebraska	19,526 "	21° " 76°	68%
Delaware	54	1,245	Wisconsin	19,505 "	16° " 70°	75%
Kansas	36	10,408	Delaware	19,390 "	34° " 77°	69%
Colorado	34	4,057	Iowa	19,206 "	16° " 74°	74%
Virginia	34	4,160	Colorado	19,160 "	29° " 72°	53%
New Jersey	32	7,810	Virginia	18,637 "	38° " 78°	70%
North Central East	2,399	443,953				
South Central East	89	25,578				

NOTE.—The F. C. M. for any record was determined by applying to it the formula 15 x fat yield + .4 x milk yield. This formula reduces the milk and butterfat production of each record to a single expression in pounds of 4% milk. See Gaines and Davidson (1923).

All states having thirty or more high record Holstein cows are states in which the temperature does not average over 78° F. during the hottest month of the year. All states having thirty or more high record Jersey cows, with the exception of Texas [16] and Tennessee [17] are also states in which the temperature does not average over 78° F. during the hottest month of the year. This limitation of the majority of the high record cows to the northern and Pacific coast states is not surprising in the case of the Holsteins, but is at first rather surprising in the case of the Jerseys. There are two-thirds as many pure-bred Jersey cows in the southern states as in the northern states, but only one-sixth as many high record Jersey cows in the southern states as in the northern states (Table VI). Hence, although the Jerseys can with-

[14] The Holstein and Jersey Breed Associations each maintain a registry of the cows of their respective breeds meeting certain butterfat requirements on a 365 day test. These production records are published from year to year and include the name of the owner of the cow and the state in which the record was made. The names of these registers and the volumes from which these records were taken are: Holstein Friesian Advanced Registry, Vols. 31 to 36, and The Jersey Register of Merit Consolidated, Vol. 1923.

[15] Owing to the greater influence of climate on the higher producing cows, this limit of 600 and 650 pounds was put upon the selection of the production records of the Jerseys and Holsteins respectively.

[16] Texas has eighty-six high record Jersey cows, but sixty-nine of them all come from the Falfurrias Farm herd. This herd is owned and operated by a very wealthy breeder and the cows are protected from exposure to adverse conditions in every possible way. Hence these records are really not comparable to other records made in the southern states.

[17] Tennessee has only thirty-seven high record cows and owing to the fact that it stands at the bottom of the average F. C. M. column, it also need not be considered as a very serious offender.

TABLE VI

PURE-BRED JERSEY COWS IN THE UNITED STATES PRODUCING 600 POUNDS OR MORE OF BUTTERFAT

States Having 30 or More Cows with Records of 600 Lbs. or Better	*Number of Records of 600 Lbs. or Better*	*Number of P. B. Animals in 1920*	*States Having 30 or More Cows with Records of 600 Lbs. or Better*	*Average F. C. M. Production of Records of 600 Lbs. or Better*	*Mean Monthly Range in Temperature and Mean Annual Relative Humidity*		
Oregon	350	7,771	Oregon	15,290	38° F.	to 67° F.	74%
Ohio	294	23,842	Connecticut	15,180	26°	" 72°	76%
New York	273	13,411	Massachusetts	15,176	24°	" 71°	76%
Massachusetts	225	2,904	Washington	15,102	40°	" 64°	77%
Washington	120	3,402	Maine	15,080	18°	" 70°	76%
Maine	113	4,999	New York	14,932	28°	" 74°	81%
Vermont	100	8,446	Ohio	14,875	30°	" 76°	70%
Michigan	99	8,296	Michigan	14,761	22°	" 71°	78%
Texas	86	18,718	New Jersey	14,745	29°	" 75°	73%
Pennsylvania	84	11,036	California	14,715	50°	" 72°	68%
Missouri	81	10,708	Iowa	14,680	16°	" 74°	74%
Connecticut	71	2,257	Pennsylvania	14,675	30°	" 73°	71%
California	58	3,832	Texas	14,637	48°	" 82°	55%
Virginia	47	3,223	Maryland	14,493	31°	" 75°	69%
New Jersey	44	1,368	Virginia	14,470	38°	" 78°	70%
Iowa	40	3,629	Vermont	14,418	15°	" 68°	76%
Tennessee	37	9,424	Wisconsin	14,378	16°	" 70°	75%
Wisconsin	37	7,791	Missouri	14,329	31°	" 76°	76%
Maryland	34	2,323	Indiana	14,192	31°	" 76°	72%
Indiana	30	9,921	Tennessee	13,913	38°	" 80°	71%
North Central East	1,585	122,627					
South Central East	268	80,414					

stand the hot, humid climate of the South, they cannot produce under such conditions and, like the other breeds, are limited to the cooler climates for high production.

All states having high record cows with the highest average F. C. M. productions, both breeds considered, are in general states having climate which is very nearly related to that of the native home of the breeds. Washington and Oregon, the only two states in the Union having climate almost identical to that of Holland and the British Isles (see Figure 22), lead the other states in highest average F. C. M. production with New York, California, and the New England coast states next in line. Hence the northern European breeds of dairy cattle, although having the ability to thrive in strange climates, do not have the same favorable physiological reactions to them as to the climates most similar to that of their native homes.

THE MICHIGAN SUGAR BEET INDUSTRY

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THE production of sugar beets is one of Michigan's stable industries. The development of the fertile beet lands of the Thumb District, and elsewhere, has done much to alleviate the burden from industrial decline brought about by the ruthless exploitation of vast timber resources on which a large population once depended for its principal source of revenue. The sugar beet industry is particularly significant in Michigan because it represents the major cash crop for many farmers; it is a valuable asset to the Dairy Region in which the beet culture is areally located, and it provides the farmer with a late season crop which is well adapted to the existing rigorous climate and short growing season.

Natural Conditions Pertaining to The Michigan Sugar Beet Industry

Michigan sugar beet culture is closely related to the conditions of the natural environment. Climate, land surface, drainage, and soils are geographic factors of major importance in the Michigan beet districts. A careful examination of these natural factors is quite necessary in order to interpret environmental relationships, to show cause for the characteristic plan of areal distribution, to advance a solution for geographic and economic problems resulting from the farm performance, and to reveal the importance of the sugar beet crop to Michigan agriculture.

Climate

The climate of the greater part of Michigan is well suited to the culture of sugar beets. The average of weather conditions for a typical station in the Thumb District, the Southeast District, and the Menominee District will serve to illustrate the climate of the most important beet-growing areas of the state (Figs. 1, 15). The summer temperature and rainfall variation in the three localities is insignificant. Although the annual rainfall at Menominee is lower, 69 per cent comes during the months from May 1 to October 30, while at Alma only 56 per cent falls during this period. The rainfall is well distributed throughout the growing season with a maximum in May, June, and July. The average amount of sunshine during the growing season has been calculated to be 67 per cent of the total sunshine period at Lansing, Michigan. Late spring and early fall frosts, and short summer droughts are common in all of the beet districts of the state.

Table I

Climatic Data for the Beet Districts of Michigan [1]

Location	*Record*	*Mean Annual Tem.*	*Mean January Tem.*	*Mean July Tem.*	*Absolute Maximum Tem.*	*Annual Rainfall*
Alma	21	45.6° F.	21.5	69.9	100	32.74 in.
Menominee	10	43.0	14.6	68.0	99	26.71
Adrian	31	48.5	23.2	74.3	102	37.03

Land Surface

The Pleistocene glaciers moulded for Michigan a land surface with a low billowy relief. The state lies wholly within the Glaciated Plains Province where the land surface varies from gently sloping lake plains to rolling, hummocky, and

[1] U. S. Weather Bureau, U. S. Dept. of Agriculture, Bulletin W, Washington, D. C.

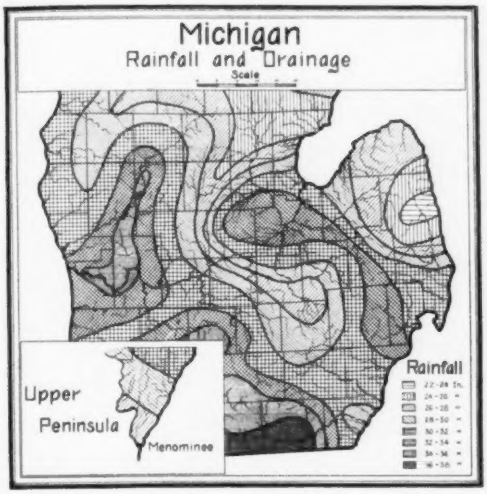

FIGURE 1.—Drainage pattern and the average annual rainfall of the Michigan sugar beet districts. The precipitation varies from 22 inches to 38 inches with a small summer maximum. The well-distributed rainfall and the tempering effect of the Great Lakes make climatic conditions ideal for sugar production.

gently undulating morainic features with numerous lakes and swamps adding to the diversity of the landscape.

The Lower Peninsula of Michigan is divided into four principal land surface regions. These major land surface divisions are: (1) the Erie Lowland, (2) the Thumb Upland, (3) the Saginaw Lowland, and (4) the Northern Upland (Fig. 2). The western border of the Erie Lowland is found near the 800-foot contour, and the nearly level plain slopes gradually to the present level of Lake Erie (573 feet above sea level).[2] The Thumb Upland, the southeastern watershed of Michigan, has a general altitude of 800 to 1,000 feet with occasional hills reaching as high as 1,300 feet above sea level. The hilly surface of the greater part of this upland stands out in marked contrast to the more nearly level lowlands of the lake plains. The Saginaw Lowland extends from Saginaw Bay in a southwesterly direction to Lake Michigan, including a strip of land about fifty miles wide extending along the Lake Michigan shore from the Manistee River to the Indiana-Michigan boundary. This lowland stands at an elevation of 600 to 800 feet, but contains a few moraines which reach an elevation of 1,000 feet. The Erie Lowland, the eastern part of the Saginaw Lowland, and the margin of the Thumb Upland contain the best agricultural lands of the Lower Peninsula when judged on the basis of soil and land surface conditions.

Drainage

The present drainage pattern of Michigan is the result of much glacial interruption of a former drainage. Marshy depressions are common in the lowlands, and also in the uplands where numerous pit-hole depressions are found among the morainic hills. Many of these pit-hole depressions cannot be drained for want of an outlet. The best drainage conditions are found at intermediate altitudes. In the higher part of the lowlands and along the margin of the uplands the gently rolling surface favors both surface and underground drainage. Seldom are the slopes steep enough to be gullied by surface erosion, and even the more level lands have enough slope to provide sufficient fall for good drainage. Considerable damage is done to land by surface erosion on the steeper hillsides of the interior upland.

The drainage of the Lower Peninsula is about equally divided between streams flowing westward into Lake Michigan and streams flowing eastward into Lakes Huron, St. Clair, and Erie. The Saginaw River drains the large central basin-like area encircling Saginaw Bay (Figs. 1, 2). The greater part of the sugar beet production of Michigan is found on the well-drained fertile lands of the Saginaw Basin, and on the margin of the Thumb Upland. Among other river systems which drain important sugar beet lands are the Raisin, Black, Menominee, and Grand.

Soil

The soil material of the sugar beet districts of Michigan is of glacial origin.

[2] I. C. Russell and Frank Leverett, Geologic Atlas of the United States, Ann Arbor, Mich., Folio, No. 155, pp. 1, 2.

The important glacial features in the sugar beet districts are lake clay deposits, moraines, bowlder clay plains, outwash plains, kames, eskers, sandy lake beds, and sandy drift.[3] These irregularly-patterned features have weathered at the surface into many soil types which vary from place to place depending largely on age, structure, texture, parent rock material, and climatic conditions. The lake clay, the clayey portion of old lake beds, has weathered into soils of high productivity when well drained. Clay loams are common but often bowlder clay occurs near the surface. The morainic deposits are extremely variable and have weathered into soils ranging from very gravelly material to heavy clay with few stones. The soils usually make good farm lands. The parent rock material of the bowlder clay plains was laid down under the ice sheet. The resulting soils range from clayey to sandy loams and make fair to good farm land. The soils formed on the sandy lake beds are rather light and generally poor in quality. The soils on the sandy drift vary somewhat but they are generally rated inferior in quality. The gravelly, sandy soils formed on kames, eskers, and outwash plains are generally second rate unless carefully tilled.

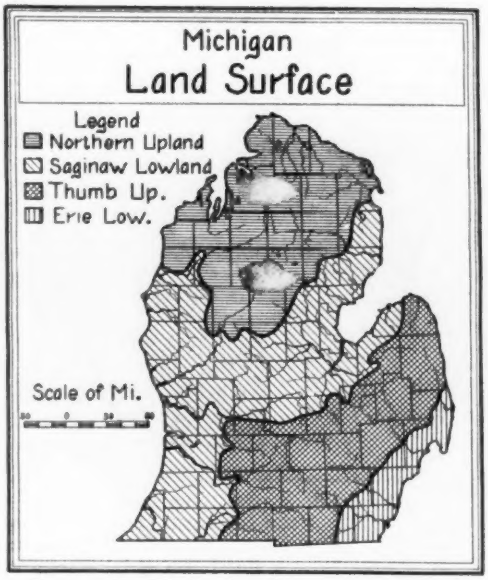

FIGURE 2.—The land surface regions of Michigan. The major portion of the sugar beet production of the state is found in that part of the Saginaw Lowland and the Thumb Upland surrounding Saginaw Bay on the west, south and east. Another producing area of some importance is found on the Erie Lowland in the extreme southeastern part of the state.

GENERAL CULTURAL FORMS OF THE LANDSCAPE

General cultural forms of the landscape contribute to the success of the sugar beet industry in Michigan. The average size of the farmsteads, the productivity of the soil, the ample means of communication, and the density of population are significant cultural elements favoring production. These cultural forms of the sugar beet districts have been slowly moulded from the natural landscape through a long period of human occupation and activity. The careful analysis of cultural forms is of paramount importance before attempting to point out environmental relationships.

FARMSTEADS

The medium-sized farmsteads predominate throughout the sugar beet districts of Michigan. The average size of farmstead has been calculated for nine counties including a fair representation selected from each sugar beet district of the state in proportion to the beet production. The results show that 40.8 per cent of the farms range from 50 to 99 acres, 26.4 per cent from 100 to 174 acres, 20.6 per cent from 20 to 49 acres, 6.8 per cent over 175 acres, and 5.4 per cent under 20 acres. Eight of these typical counties show an average of 86.3 per cent of the total area in farms, and 77.4 per cent of the total farm land improved.[4] The majority of farmsteads contain small woodlots, well-fenced fields, some tile drainage, good buildings, and other general marks of prosperity (Fig. 3).

[3] Frank Leverett, Map of the Surface Formations of the Southern Peninsula of Michigan, Geological Survey, Lansing, Mich.

[4] Census Report, 1920, U. S. Bureau of Census, Washington, D. C.

FIGURE 3.—The majority of farmsteads in the sugar beet districts contain small woodlots, well-fenced fields, good buildings, and other general marks of prosperity. The numerous silos indicate the presence of a well-established dairy industry. Notice the general levelness of the sugar beet lands. (Courtesy of the Menominee River Sugar Company.)

PRODUCTION

The uniformly high quality of the sugar beet lands of Michigan is shown by the character of crop production on these lands when climatic conditions are favorable. Excluding occasional droughts or prolonged rainy spells, one is able to see excellent crops of hay, wheat, oats, barley, rye, beans, peas, corn, potatoes, vegetables, and fruits in the fields where sugar beets find an important place in the rotation scheme. Many dairy cattle and a few beef cattle can be seen feeding in adjacent meadows (Fig. 4). Numerous silos point to a well-established dairy industry. Tuscola County with 32,475 dairy cattle (40 per square mile) and 11,695 beef cattle reported in 1920 is a typical example of the extent to which the dairy industry is practised in the beet-growing counties. Generally, each farmer owns a small herd of cattle, but occasionally large

FIGURE 4.—The largest acreage of sugar beets is grown on the Brookston soils which are found on low-lying plains. This fertile plain gives way to higher morainic country in the distance. The normal specimen of sugar beet indicates that this well-drained fertile soil is properly tilled. A small herd of dairy cattle can be seen in the adjacent meadow. (Courtesy of Michigan Sugar Company.)

FIGURE 5.—A network of railroads furnish the sugar beet districts of Michigan with ample transportation facilities. Notice the position of the cities containing sugar factories in relation to the lines of railway. Most of these railroads which were built when Michigan was a leading lumber state have now to depend on subsequent industries for support. The sugar beet industry furnishes the railroad lines with approximately one and one-half million tons of freight annually.

herds are found near the cities and villages. The production of dairy products in a beet-growing district has long since proved to be a profitable business as well as a necessary part of the farm economy.

COMMUNICATION

The sugar beet districts of Michigan are well supplied with lines of communication. The large profits from a thriving lumber business which reached its peak of production in 1890, furnished the incentive for the construction of numerous lines of railway which form a veritable network of routes for rapid transportation service in the lower part of the Southern Peninsula (Fig. 5). With the passing of the lumber business the railroads in the south part of the state received ample support by transporting the products of subsequent industries. This is particularly true in the sugar beet districts where agriculture became well established on the better lands, and where various manufacturing industries prevented decadence in the urban centers which were formerly supported by the exploitation of extensive timber resources in the surrounding country. For the most part, the farms in the sugar beet districts are less than six miles from a railroad. Good public highways are constructed with gravels which are taken from pits in well-distributed glacial deposits containing an abundance of this cheap, durable road material. In most places roads have been constructed around each square mile of land surface where feasible. Many of the trunk-line highways have been constructed of concrete. Transportation lines are everywhere favored by low relief.

DISTRIBUTION OF POPULATION

A careful survey of the rural and urban population distribution was made for the Thumb District where about 90 per cent of the sugar beets of the state are produced. The larger urban agglomerations are found in the Saginaw Valley. Flint (91,599 people in 1920), Saginaw, Bay City, Owosso, Alma, Mt. Pleasant, and Midland are the larger cities which are located on the Saginaw River or its tributaries. Many small cities and villages are evenly distributed throughout the district.

The rural population varies from 16 to 140 people per square mile. Townships which show a density of more than 60 people per square mile surround the larger urban agglomerations like Flint, Saginaw, or Bay City. A sparsely populated area with less than 15 people per square mile in Midland and Arenac Counties coincides with a body of sandy soil which is characteristic of the Pine Sand Plains of the northern part of the Southern Peninsula, and which is unfit for agriculture (Fig. 6). Because of the poor soils this area is not included in the Thumb Sugar Beet District. The rural population in a majority of the townships range from 16 to 45 people per square mile. With some mineral resources, with negligible timber resources, with an average of 6 to 10 families per

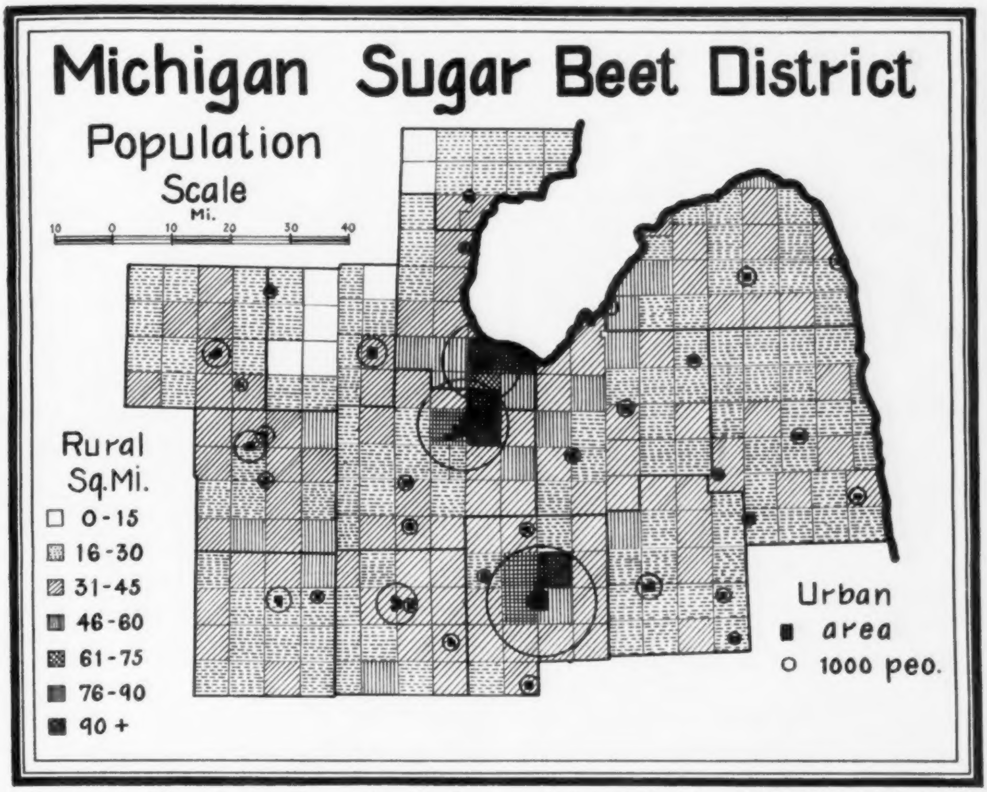

FIGURE 6.—Map showing the rural and urban population of the Thumb District. This district supports a large rural and urban population except in the north central part, where the sandy soils, once covered with pine forests, are too infertile for sugar beet culture. The solid black indicates the exact area occupied by the city, while the circle indicates the relative size of the population.

square mile, with all townships having 16 or more people per square mile, with three cities ranging from 47,500 to 91,500 people, with 28 smaller cities and villages ranging in size from 700 to 5,000 people, the Thumb Sugar Beet District has the appearance of extensive agricultural and industrial development. Many of the urban people are supported by industries which are direct outgrowths of agriculture.

SPECIFIC CULTURAL FORMS RESULTING FROM THE SUGAR BEET INDUSTRY

Distinct cultural forms of the landscape result from the production of sugar beets in Michigan. Beet fields, loading stations, portable homes of the laborer, and sugar factories are among these cultural features. The early morning song of the satisfied foreign laborer is often heard reverberating harmoniously from yonder timber as he leaves his humble summer home en route to neighboring beet fields. These cultural forms operate in an amalgamated unit closely adjusted to natural conditions, resulting in general prosperity for the beet farmers, and contentment among the laborers.

BEET FIELDS

Beet fields form a conspicuous part of the landscape in many parts of the Saginaw Basin. The beet fields are more numerous along the railroads, and decrease rapidly with distance from the railroads. The accompanying diagram showing the position of beet fields in the landscape which surrounds a Loading Station on the Ann Arbor Railroad in the southeastern part of Isabella County

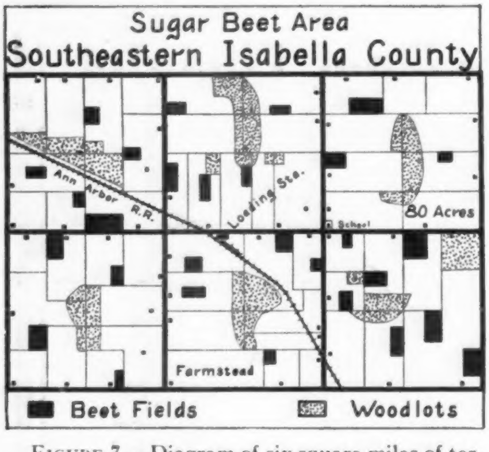

FIGURE 7.—Diagram of six square miles of territory surrounding a loading station on the Ann Arbor Railroad in the southeastern part of Isabella County. The farmsteads vary in size from 25 to 240 acres, but most of the farms contain from 40 to 80 acres. The beet acreage ranges from 4 to 20 acres per farm. This area shows the characteristic concentration of beet fields around the loading stations on the railroad lines of the Thumb District. It should be pointed out, however, that the production area has been greatly extended in recent years through the use of trucks for transporting the crop to the loading station or factory.

illustrates the concentration of production in a locality where climate, soils, and transportation are favorable factors (Fig. 7). Within this area of six square miles, representing land in four townships where agriculture is at its best, there are 54 farms out of which a total of 28 farms are regularly producing sugar beets. In this locality as in most parts of the Thumb District, it is difficult to find many beet fields more than five miles from a Loading Station because of the high transportation cost. However, where improved roads have been constructed, the use of trucks has resulted in a considerable extension of the beet-producing areas.

There is a decided variation in the size of the beet acreage per farm. At Caro, Tuscola County, 134 farm records show the average beet acreage per farm to be 15.1 acres which is 18.23 per cent of the tillable area. At Alma, Gratiot County, 53 farm records show the acreage to be 9.54 acres, or 12.81 per cent of the tillable area.[5] In the western part of the state where production is very scattered, the average acreage from 36 farm records is 6.4 acres, or 7.17 per cent of the tillable area. It is quite true that the average acreage decreases with the distance from the center of production which is in the Thumb District just south of Saginaw Bay in eastern Bay and northwestern Tuscola Counties (Figs. 8, 9).

LOADING STATION

Loading Stations are found at frequent intervals along the railroads of the Saginaw Valley. These stations are generally from two to four miles apart. The station comprises about ten acres of land on which a side track and a building con-

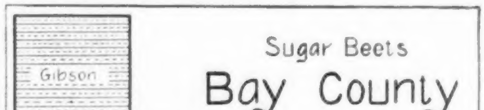

FIGURE 8.—Sugar beet production in Bay County for 1922 by townships based on careful estimates by field representatives of the sugar companies. Ports Mouth and Merritt Townships have 7 per cent or more of their total area planted to sugar beets annually.

[5] U. S. Dept. of Agriculture, Bulletin No. 748, Farm Practice in Growing Sugar Beets in Michigan and Ohio, 1919, p. 43.

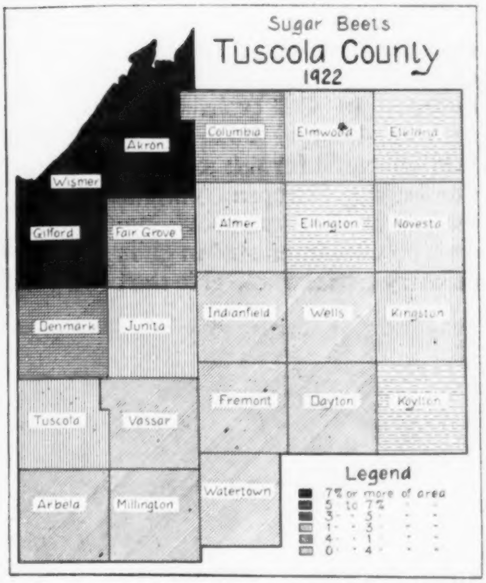

FIGURE 9.—Sugar beet production in Tuscola County according to field estimates for 1922. Akron, Wismer and Gilford Townships, together with Ports Mouth and Merritt Townships, Bay County, form the nucleus of beet production for the Thumb District. The average farm acreage of sugar beets for this section is slightly more than fifteen acres.

taining adequate weighing and taring facilities are constructed. The extra land is used for dumping space when cars are not available. Each sugar company provides its own loading stations through agreements with the railroad companies. One station will serve a surrounding area with a four to six mile radius. The service areas of the various sugar companies often overlap or even coincide.

THE PORTABLE HOME OF THE LABORER

Temporary movable quarters are usually provided for the contract labor doing handwork on the beet crop. A small horse-drawn cabin is often provided because it can be conveniently moved from one field to another. Portable one-room shanties are used in some localities. Occasionally vacant farmhouses of the community provide a temporary home for the laborer and his family during the beet season. These temporary dwellings are occupied from May until December.

SUGAR FACTORIES

Thirteen sugar manufacturing plants are advantageously distributed in the landscape of the Thumb District. One plant is also located in each of the outlying districts where the production of beets is more or less scattered over a large territory (Fig. 10). The Michigan Sugar Company has a factory at Bay City, Caro, Alma, Owosso, Lansing, Sebewaing, Carrollton, and Croswell; the Columbia Sugar Company at Bay City and Mt. Pleasant; the Holland-St. Louis Sugar Company at Holland and St. Louis; the Continental Sugar Company at Blissfield; the West Bay City Sugar Company at West Bay City; the Menominee River Sugar Company at Menominee; and the Mt. Clemens Sugar Company at Mt. Clemens. The Independent Sugar Company of St. Clair has ceased operations. Each plant carries out the complete manufacturing process beginning with the raw beet and ending with the refined sugar (Fig. 11).

FIGURE 10.—Location, relative size of production for the period 1920–1924, and ownership of the beet sugar factories operating in the state of Michigan. The Michigan Sugar Company is the largest producer of beet sugar with eight large plants in the Thumb District. The Independent Sugar Company ceased operation in 1922.

DEVELOPMENT OF THE INDUSTRY

The sugar beet industry has done much to stabilize Michigan agriculture. During the last decade Michigan has become one of the four leading sugar beet producers of the United States. In fact the state has risen to second place in recent years when ratings are figured on the basis of total acreage, total beet tonnage and total tonnage of refined sugar.

ORIGIN OF THE INDUSTRY IN MICHIGAN

The first agitation for the development of a sugar beet industry in Michigan was started in 1891 by R. C. Kedzie, chemist at the Michigan Agricultural Experiment Station. Dr. Kedzie wrote an article on sugar beets, after extensive study and experimentation, which was carried to the farmers of the state through the Monthly Bulletin published by the Experiment Station for free distribution. The author pointed out the similarity between the climate of Southern Michigan and the beet-growing areas of Germany and France, the kinds of soils for beets, facts about planting and cultivation, and the progress of the beet industry in California and Nebraska. Further, he told how the Experiment Station would furnish samples of four of the leading European varieties of beet seed on application, providing the farmers who were interested in giving the new industry a trial would give the beets good care, and return an accurate report together with specimen beets for analysis. Many farmers showed keen interest in the scheme by ordering seed for the initial trial cultivation during the summer of 1891.

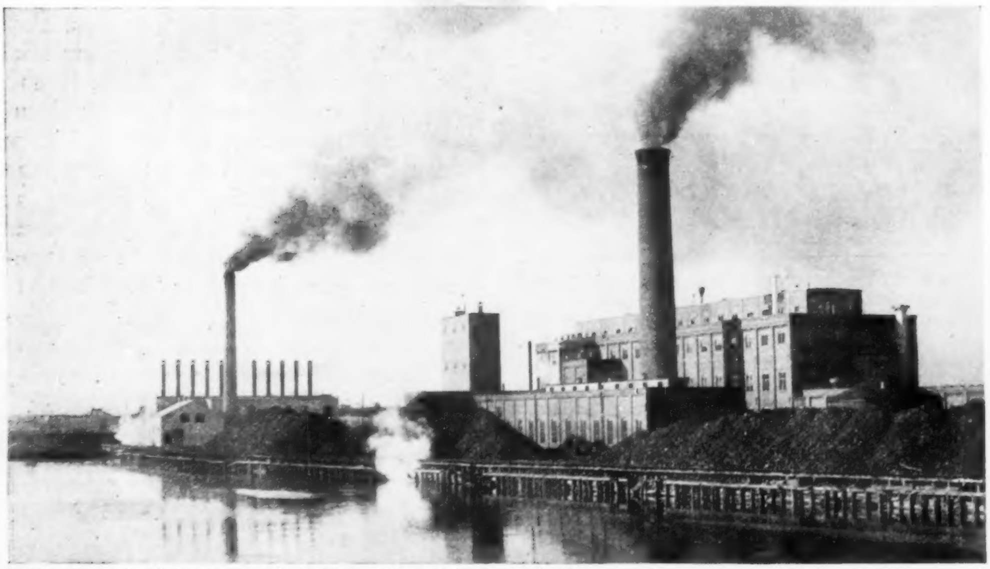

FIGURE 11.—The Menominee River Sugar Company's plant at Menominee, Mich. This factory is located on the bank of the Menominee River where a good water supply and cheap water transportation is always available. All of the sixteen Michigan sugar factories are located on large rivers. A factory with a daily slicing capacity of 1,000 tons requires from 2½ to 3 million gallons of water per day. (Courtesy of Menominee River Sugar Company.)

In March of the following year Dr. Kedzie published another bulletin in which he presented most gratifying results of the first attempt to grow beets. Chemical tests were made on beets grown by many farmers in 39 well-distributed counties of the Southern Peninsula.[6] The high yield on certain soils, and the high

[6] Kedzie, R. C., Report on Sugar Beet Culture in Michigan, Monthly Bulletin, Experiment Station, March, 1891, 1892, East Lansing, Mich.

sugar content of most specimens proved conclusively that a large part of Michigan was a natural home for the sugar beet.

There was much discussion among the farmers in favor of the sugar beet industry. Many wanted to grow beets but there was no market for the roots. The U. S. Department of Agriculture became interested in the sugar beet possibilities of Michigan, and, in 1897, fostered a second trial cultivation by furnishing the farmers with a quantity of seed. The report on production in 64 counties was made in the December Bulletin of the Experiment Station. Stimulated by the excellent results of the second trial cultivation, three men of Bay City, Michigan, namely, Thomas Cranage, E. Y. Williams, and N. B. Bradley, went West to look over some sugar plants.[7] They finally concluded to build a plant at Bay City, where in 1898 the first sugar factory of the state was operated under the name of the Michigan Sugar Company.

The State Legislature passed a law in 1897 stating that any person or corporation entering into the manufacture of sugar from beets would receive a bounty of one cent per pound. Consequently, factories were built in Michigan faster than the farmers could be educated to grow beets and the result was that many of the factories became unprofitable. Factories were built at Benton Harbor, Kalamazoo, Rochester, Charlevoix, East Tawas, Saginaw, and Bay City. In 1898, the Supreme Court declared the bonus law unconstitutional and all of the sugar factories failed or moved out of the state.

During the following year factories were erected at Bay City, Caro, Alma and Holland. The majority of the present factories were erected during the period from 1899 to 1905.[8] The high tariff (1.685 cents) from 1897 to 1903 gave impetus to the beet industry and the production increase from 219,480 tons of beets in 1900 to 517,527 tons in 1904

FIGURE 12.—The first statistics by counties on the sugar beet production of Michigan were taken in 1900. This map shows the production in all counties producing more than 500 tons of beets annually. During the 1890s sugar beets were produced in small quantities in 80 per cent of the counties of the state largely as an experiment. By 1900 the industry was well established in the townships of Bay and Tuscola Counties bordering on Saginaw Bay.

(Figs. 12, 13). The sugar beet industry of Michigan could not exist without a high tariff to protect the industry from foreign competition. Obviously, the beet farmers favor a high tariff on sugar in order to keep the price high enough to allow them to produce sugar beets at a profit. The industry has suffered at times from low prices, but nevertheless the growing of sugar beets is one of the best agricultural industries of the state. It has given employment to a greater number of people than any other agricultural industry. It is true that the Thumb District and the Southeast District are two of the most prosperous agricultural sections of Michigan. This statement is made after careful field observations in many parts of the state.

TREND OF PRODUCTION

The development of the sugar beet industry of Michigan can be divided into

[7] Notes from the "History of Michigan Sugar Company," Bay City Plant, Bay City, Mich.
[8] Truman G. Palmer, "Sugar Beet Industry of the United States," 1913, Union Trust Building, Washington, D. C., pp. 83-97.

FIGURE 13.—By 1904 the industry showed considerable growth towards the interior. The fertile, easily drained lands of Gratiot County, one of the leading agricultural counties of Michigan, has become a leading sugar beet producer. The Thumb Upland also shows considerable increase in production. (Statistics by counties.)

three distinct stages: the experimental stage, the stage of rapid expansion, and the stage of stability. The period from 1891 to 1899 one would call the experimental stage because beets were raised on all grades of land largely as an experiment, and in most instances fed to livestock for want of a better market. Beets were produced in small quantities in 80 per cent of the counties of the state. The stage of rapid expansion extending from 1899 to 1910 is characterized by the development of a satisfactory market through the erection of numerous sugar factories, by a rapid increase in production (Figs. 12, 13, 14), and by a contraction of the producing area to districts having extensive bodies of the favorable soil types (Figs. 21, 16, 14). A total of 78,998 acres (1904–1909 average) yielded 616,000 tons of beets which produced 75,405 tons of refined sugar.[9] The production of beets has been relatively stable since 1910, and has continued on the better lands for the most part. The production curve oscillates along a nearly horizontal line from that date (Fig. 23). This oscillation is due to unavoidable geographic and economic circumstances such as weather, beet pests, and sugar prices. During the period from 1909 to 1924, the average production was 118,476 acres, yielding 965,900 tons of beets which produced 116,032 tons of refined sugar.

THE STATUS OF THE INDUSTRY

Sugar beet culture is one of the major agricultural industries of Michigan. Since 1909 the yearly acreage is found to be between 100,000 and 150,000 acres excepting the lean years of 1916, 1917, and 1922, when the acreage declined to a little more than 80,000 acres due to the fact that higher prices were paid for other agricultural products which were in great demand in foreign countries. These facts indicate that the industry is well established in the state, and that it has remained relatively stable during a period filled with a great variety of eco-

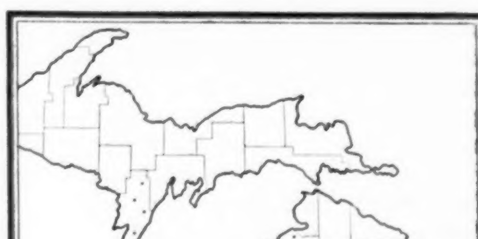

FIGURE 14.—The production of 1910 is characterized by a further increase in the counties of the Eastern Saginaw Lowland and the Northeastern Thumb Upland having large bodies of fertile sugar beet soil. (Statistics by counties.)

[9] U. S. Dept. of Agriculture, Year Books 1904–09, Washington, D. C.

nomic circumstances resulting from the World War. The average sugar beet acreage in Michigan for the period 1919–1924 is 122,765 acres, or 13.4 per cent of the average acreage (913,273 acres) grown in the United States during the same period.[10] Colorado was the only state to surpass Michigan in acre production with 20 per cent of the total acreage of the United States.

The average field returns computed from figures compiled by the United States Sugar Manufactures' Association during the period 1919–1924 for the four leading states of the country present some very striking facts. In average yield per acre, Utah ranks first with 11.33 tons, while Michigan holds third place with 8.55 tons. In the total tonnage of beets harvested, Colorado assumes first place with the sum of 1,966,229 tons (28.1 per cent of 6,993,890 tons harvested in the U. S.) harvested, while Michigan holds third place with 1,050,373 tons (15 per cent). A similar rating appears when the sugar beet production is calculated on a basis of total farm value of beets.

The status of the Michigan sugar beet industry takes on a still different appearance when judged by the factory returns for the aforesaid period. Colorado retains the lead in the total number of tons of refined sugar produced with 241,413 tons, while Michigan is forced to accept fourth rank with 121,986 tons (13.9 per cent). California, rated lowest on the field production returns, leads all of the states in regard to the sugar content of the beet, while Michigan occupies fourth place on this score. The magnitude of the sugar beet industry by states is most accurately determined through the total production of refined sugar.[11] The four leading states (1919–1924 average) arranged in order of importance on this score are (1) Colorado, (2) Utah, (3) California, (4) Michigan. It should be pointed out, however, that Michigan leads in the farmers' receipts per pound of sugar recovered because of the nearness to good markets, and also that she held second place in 1924 on the basis of refined sugar produced. When figured on the basis of the 1920–1924 average, the rating as to beet tonnage and refined sugar is (1) Colorado, (2) Michigan, (3) Utah, (4) California (Figure 21). These four states produce 71.5 per cent of the beet sugar manufactured in the United States. It is quite true that the development and present status of the sugar beet industry of Michigan can be explained to a large extent on the basis of geographic forms which perform vital functions in the industrial fabric.

Figure 15.—The map of the areal distribution of sugar beet production for 1920 shows the greatest concentration in the Thumb District, where the industry has been relatively stable during the past fifteen years. Large bodies of favorable soil is the major geographic factor influencing this distribution. (Statistics by counties.)

Farm Practices as Related to Natural Conditions

The conditions of the natural environment bear a close relation to the farm practice in the Michigan sugar beet districts. Climate and soils are the major

[10] Truman G. Palmer, "United States Sugar Beet Production by States," 1919–24, Final Report, Loose Leaf Service, Union Trust Building, Washington, D. C.

[11] *Ibid.*

factors which influence production. Beet tonnage is largely dependent on soil fertility and rainfall, while the sugar content is dependent on temperature and sunshine. A cool fall with a normal well-distributed rainfall and abundant sunshine is the optimum.

PRODUCTION AS RELATED TO CLIMATE

Temperature is the dominant factor in producing a high sugar content in beets. Beets do not want extremely high temperatures during the growing season. Whenever the temperature goes above 70° F. the sugar content decreases. This fact has been definitely proven by Dr. Harvey W. Wiley with many thousand experiments.[12] A climate with cool summers is best suited to the growth of beets with a high sugar content. The low temperatures of late fall are not injurious to beets which are often harvested in Michigan after the ground becomes slightly frozen from the evening chill. The May to November mean temperature is at Caro 62.5° F., and at Alma 61.4° F. The climate of the Thumb District, which is tempered by the influence of Saginaw Bay and Lake Huron, is very favorable for the growth of beets with a high sugar content. This is likewise true of other Michigan Districts which are largely located adjacent to shores of the Great Lakes.

The sugar content of beets increases directly with the amount of sunlight. Beet sugar is a carbohydrate which is gathered from the atmosphere by the aid of light and stored in the root of the plant.[13] The amount of sunshine recorded during a typical year at Lansing, Mich., is for April, 66 per cent; May, 53 per cent; June, 76 per cent; July, 65 per cent; August, 72 per cent; September, 74 per cent, and October, 64 per cent, of the sunshine period. The long summer days of Michigan furnish ample sunlight for the growth of sugar beets of high quality.

Since the sugar beet receives its sugar content from the air, the presence of winds are of no little importance in beet culture. Michigan is in the path of the strong Prevailing Westerlies and the air is generally moving quite freely in the form of wind. There are few days in the summer when the air is calm and stagnant. The cool winds which sweep off the lakes help to lower the temperature and keep the beet plants well supplied with carbon dioxide, oxygen, and hydrogen, which are formed into sucrose ($C_{12} H_{22} O_{11}$) at the under, outer edge of the leaves from where it is transported through the leaves to the root.

The amount and distribution of rainfall affects the tonnage, but has slight effect on the sugar content. Michigan rainfall which varies from 22 to 38 inches in the beet districts is well distributed with a slight summer maximum (Fig. 1). Droughts seldom occur and consequently good yields are obtained where the ground is properly tilled and drained. Heavy rainfall near the harvest season increases the sap in the beet and slightly lowers the sugar content. The Michigan districts are favored with moderate rainfall in October when most of the beets are harvested. Beets make rapid growth in the fall and store more sugar at that time. An average amount of rain and plenty of sunshine is the optimum for September and October.

TABLE II

MEAN MONTHLY RAINFALL DURING THE GROWING SEASON FOR TYPICAL STATIONS IN THE MICHIGAN BEET DISTRICTS

Station	*Record*	*April*	*May*	*June*	*July*	*August*	*September*	*October*
Caro	21	2.71	4.14	3.20	3.13	2.79	2.80	2.70
Alma	21	2.39	3.56	3.07	3.11	2.73	3.28	2.61
Adrian	31	2.56	4.29	4.28	3.61	3.30	3.35	2.85
Menominee	10	1.75	3.25	3.31	3.94	2.52	3.43	2.22

[12] Dr. Harvey W. Wiley, Bureau of Chemistry, Bulletins Nos. 64, 74, 78, 95, and 96, Wash., D. C.

[13] Truman G. Palmer, "Questions and Answers Concerning Sugar," 1917, Union Trust Building, Washington, D. C., p. 39.

TABLE III

NORMAL RAINFALL AND SEASONAL RAINFALL CONDITIONS AT ALMA, OWOSSO AND BAY CITY DURING CHARACTERISTIC YEARS

ALMA

	Sept.	*Oct.*	*Nov.*
Normal Rainfall......	3.81 In.	2.61	2.60
Fall of 1908..........	.65	.80	2.82
" " 1920..........	2.61	1.45	1.98
" " 1911..........	5.36	5.77	3.18

OWOSSO

Normal Rainfall......	2.64	2.62	2.46
Fall of 1908..........	.70	.80	2.61
" " 1920..........	2.10	1.54	2.55
" " 1911..........	6.01	5.91	4.95

BAY CITY

	Sept.	*Oct.*	*Nov.*
Normal Rainfall......	2.97	2.63	2.36
Fall of 1908..........	.50	1.10	2.81
" " 1920..........	1.58	1.91	2.46
" " 1911..........	7.85	7.40	5.56

Note.—Referring to Figure 23, one can readily see that a dry fall which is accompanied with much sunshine results in a lower beet tonnage but relatively larger sugar content. A year with well distributed normal rainfall and sunshine gives an average tonnage with a high sugar yield. On the other hand, a very wet fall with little sunshine gives a very large tonnage but a comparatively low sugar yield. In 1911 and 1920 the acreage was about the same, but in 1908 only about four-sevenths as much. (After U. S. Weather Records.)

IMPORTANCE OF WELL-DRAINED FIELDS

Drainage is a big factor in obtaining maximum beet yields and sugar content. Many farmers of the state are attempting to grow beets on poorly drained fields with the result that the average yield and sugar content for Michigan beets is generally lower than those of Colorado, Utah, California, and Nebraska. Good drainage has the advantage of (1) early preparation of the seed bed, (2) warming of the seed bed by decreasing evaporation, (3) increasing the feeding area of the plant by lowering the water table which in turn insures the beet against drought by stimulating deeper rooting, (4) permitting cultivation and weeding at all times, and (5) preventing the destruction of soil structures at the time of harvest.[14] Poor drainage gives rise to abnormal root development of beets resulting in greater tare and less tonnage, and produces more sap with a lower sugar content.

Beets grown on the irrigated lands of California, Colorado, and Nebraska show a greater yield per acre and a greater sugar content. This is attributed to the fact that the soil moisture is properly regulated during the growing and harvest seasons. Michigan has only a few thousand acres of irrigated lands on which some beets are grown, but the yield and sugar content of beets grown on non-irrigated lands can be greatly increased by adequate drainage.

DISTRIBUTION OF SATISFACTORY SOILS

Beets do best on fertile well-drained loam, silt loam, and clay loam soils. Michigan beets are largely produced on four types of soils, all of which belong to the group of heavier soils. The four soils comprise the Brookston, Kewaunee, Napanee, and Miami.[15] The Brookston group of soils is known as the swamp border type because of their low lying position on flat plains, or along the margin of swamps; is forested with elm, ash, hickory, swamp white oak, and soft maple; is well supplied with plant food; and is rated the best sugar beet soil of the state when well drained. A yield of 10 to 16 tons of beets per acre is obtained on Brookston soils. The Kewaunee soil is found on gently rolling land surface, is timbered with beech, hard maple, oak, and some pine; and is rated very desirable for sugar beets with yields approximating the Brookston soils. The Miami group is found on more irregular land surface, is variable in fertility because of longer cropping, and extensive surface erosion which has often completely removed the humus layer; is forested with beech, hard maple, and oaks; and is rated a fair beet soil where surface erosion has not been active. Beets cannot be grown on slopes where surface erosion is active

[14] O. E. Robey, "Tile Drainage," address before the Sugar Beet Institute, 1924, East Lansing, Mich.

[15] M. M. McCool, "Sugar Beet Soils," address before the Sugar Beet Institute, 1924, East Lansing, Mich.

TABLE IV

ADVANTAGES OF SUGAR BEET CULTURE FOR THE FARM

(Average Crops per Acre in Pounds)

	Before Beet Culture	*After Beet Culture*	*Increase*
Wheat.......	1,848 lbs.	2,292	444
Rye..........	1,456	1,672	216
Barley........	1,672	2,094	422
Oats..........	1,355	1,918	563
Peas..........	985	1,834	849
Potatoes......	6,716	13,590	6,874

NOTE.—The preceding experiment was conducted on thirty-five farms of 500 to 1,000 acres in Saxony Province, Germany. Each crop showed an increase in yield following sugar beets in the rotation which is conclusive evidence that sugar beets have a beneficial effect on the soil in relation to other crops. (From Tariff Information, 1921, "The Beet Sugar Industry," by R. G. Palmer to the Ways and Means Committee, House of Representatives, Washington, D. C.)

because the beets become exposed to the light, and the exposed part of the beet has a very low sugar content, and also contains substances which interfere with the manufacturing process. The Napanee soil is associated with the Brookston and the Miami types, is forested with hickory, elm, and oak; is generally quite fertile, is difficult to keep in good tilth, and is a good beet soil when well drained and properly tilled.

The areal distribution of the four types of sugar beet soils in the Southern Peninsula is an important geographic consideration. Soil area No. 1 comprising the greater part of the Thumb District and the Southeast District has the largest acreage of Brookston and Napanee soils (Fig. 16). Soil area No. 2 which includes the margin of the Thumb District and the Southeast District has the largest acreage of Miami with Brookston and Napanee subordinate but in considerable acreage, and coincides fairly well with the Thumb Upland. Area No. 3 includes scattered bodies of Kewaunee located in the central part of the state. Area No. 4 located in the southwest part of the state contains scattered bodies of Miami, Napanee, and Brookston. The majority of Michigan beets are grown on Brookston, Napanee, and Miami soils. On the basis of soil types there is considerable room for expansion of the beet industry in the south half of the Southern Peninsula.

The sugar beet crop removes less fertility from the soil than any other Michigan cash crop when the tops are returned to the soil. Furthermore, the beet plant improves the mechanical and physical condition of the soil through its extensive fibrous root system (Fig. 20). Tonnage depends on both soil fertility and atmospheric conditions, while sugar content depends more on the atmospheric conditions during the growing season. Many Michigan beet farmers maintain a high soil fertility through the practice of crop rotation, and the use of fertilizers. A common rotation is clover; corn, beans, or potatoes; beets; oats, barley, or rye, seeded to clover; so that beets appear in the rotation every third or fourth year. Through rotation the land is kept in good tilth, and free from beet diseases. Fertilizers are quite extensively used in the better districts and materially increase the tonnage.

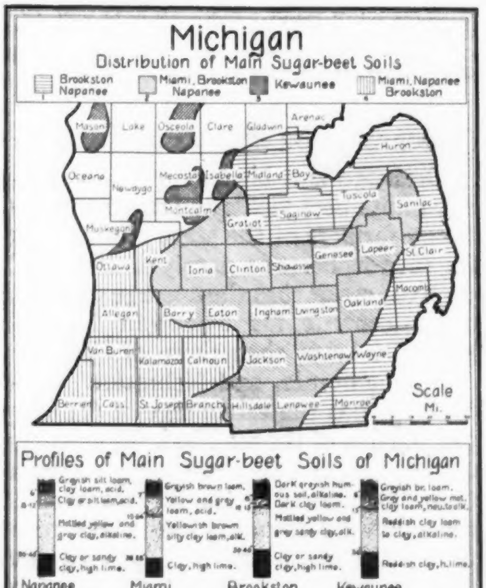

FIGURE 16.—Distribution of the principal sugar beet soils of Michigan. The four leading sugar beet soils are Brookston, Napanee, Miami, and Kewaunee. The Brookston soil has a very dark grayish humus layer at the surface and is the most desirable soil for sugar beets. A careful comparison of the above soil profiles is worthy of attention. (After M. M. McCool, soil specialist, East Lansing, Mich.)

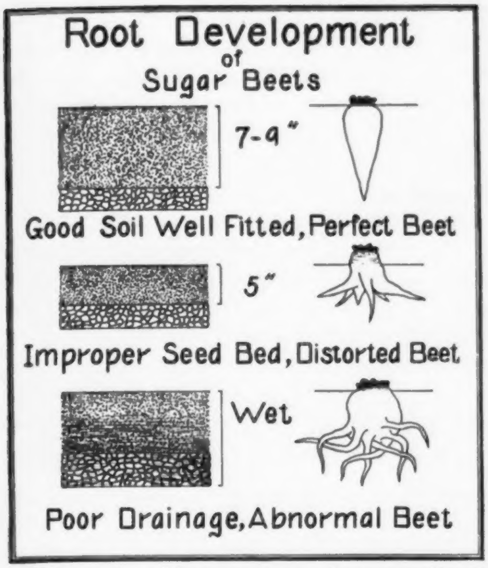

FIGURE 17.—The importance of proper soil and drainage conditions in the production of sugar beets is shown by the nature of the root development. Distorted or abnormal root development results in excessive tare, lower tonnage, and a smaller sugar content.

Most Michigan beet farmers have learned the value of good tillage. They have learned that when the seed bed is not well prepared to a depth of 7 to 10 inches the beets grow into distorted shapes causing a great economic loss through excessive tare, lower tonnage, and smaller sugar content (Fig. 17). Consequently, the better farmers of the Thumb District devote more time to the preparation of a seed bed for beets than for any other crop.

HARVEST AS RELATED TO NATURAL CONDITIONS

Sugar beets make an ideal cash crop for localities with a short growing season and a cool continental climate. While most farm crops are stimulated to ripen by the coming of cool weather in the fall, the sugar beet makes its rapid growth at that time. The beets are left in the ground until the lower leaves turn brown. The sugar beet harvest comes after all other crops are pretty well out of the way thus aiding the farmer in the seasonal distribution of labor. Michigan beet harvest starts in late September and continues through October and into November. Freezing does not injure the beets materially, but repeated freezing and thawing makes sugar extraction difficult. To prevent freezing and excessive loss of moisture after topping, the beets are placed in piles and covered with the tops. Sugar beets can be left in the ground long after freezing temperatures occur in the fall. The beet crop, the last crop to be harvested in the fall, fits well into the economic scheme of crop rotation.

CONTRACTS AND LABOR

Michigan farmers grow beets under contract with the sugar companies. The farmer knows the price to be paid for his beets, and the cost of hand labor per acre before the beets are planted. In this way he is protected by the companies against price changes due to unforseen circumstances. Some farmers perform all of the labor function, but generally they contract for the hand labor and do the cultivating and hauling themselves. The representatives of the Michigan Sugar Company,[16] and other companies as well, act as missionaries for the beet growers in that the representatives go into the industrial centers where these common laborers reside, present to them contracts offered by the farmers, and supervise the moving of the laborers and their household effects to the beet districts with a minimum amount of trouble and expense to the farmer. If the farmer is not amply supplied with working capital, the sugar companies advance cash to the laborers for duties performed in connection with the beet crop as per contract, and deduct these advances from the farmer's credits for beets delivered at the end of the crop year. Where necessary the companies furnish the farmer with beet seed, fertilizer, and farm implements on the same basis. The hand labor on beets is very great and much labor has to be imported during the summer to care for the indus-

[16] Notes by F. L. Crawford, Secretary of the Michigan Sugar Co., Detroit, Mich.

try. Mexican labor is much in evidence in recent years. Child labor is utilized to some extent without any injurious effects (Fig. 18).

MARKETING PERFORMANCE

A satisfactory marketing performance demands ample transportation and marketing facilities, together with localization of sugar factories within the beet districts.

TRANSPORTATION AND MARKETING

Sugar beets are a heavy bulky commodity. In order to lighten the transportation burden for the farmers, loading stations are located at advantageous points along the railways. In the Thumb District the average hauling distance for the farmer is 2.47 miles.[17] The use of motor trucks has made it possible to grow beets at a greater distance from the loading stations and factories, but only a relatively small tonnage until recently has been transported in this way because beet culture is somewhat intensive agriculture and is carried on mostly by the owners of small farms. However, the use of trucks is increasing yearly. The Columbia Sugar Company is employing motor trucks almost exclusively. The trucks are largely owned by men who make a business of trucking, and the trucks are secured for the farmers by representatives of the sugar company.

At the loading station the weight and tare is taken for each load of beets which are then loaded on railway cars for transportation to the sugar factory. If cars are not available, the beets are dumped in large piles to await rail transportation. On account of the great bulk and the rapidity of marketing in the more productive districts, the latter practice is very common. The beets are sometimes left in piles until they become a frozen mass necessitating the use of a pick at the time of removal. The losses are not great from this practice because the sugar beet is naturally well adapted to a rigorous climate.

FIGURE 18.—A large amount of labor is necessary to produce sugar beets successfully. The planter usually takes care of the cultivation and the hauling, but the hand labor is performed by contract labor. Besides blocking, thinning and hoeing, the laborer is required to pull and top the beets in the fall. The mother and children often share a part of the labor burden without any ill effects. (Courtesy of Menominee River Sugar Company.)

LOCALIZATION OF SUGAR FACTORIES

The sugar beet factory is surrounded by beet fields. The beet sugar factory is one of the few manufacturing estab-

[17] U. S. Department of Agriculture, Bulletin No. 748, *op. cit.*, p. 29.

lishments which must be located at the source of raw material (Figs. 10, 15). The transportation cost of the raw material is greater than the transportation costs of the by-products which are largely consumed locally, of the fuel, and of the refined sugar, necessitating the location of the factories at advantageous points among the beet fields. The Thumb District enjoys the advantage of enveloping the workable area of the Michigan Coal Field where a fuel supply can be cheaply secured.

The distribution of factories in the landscape is largely determined by a source of water supply. A sugar factory with a daily slicing capacity of 1,000 tons requires between 2½ and 3 million gallons of water per day. The average slicing capacity of all Michigan factories is about 900 tons. The distribution of factories is closely related to the drainage pattern. The 16 factories operating in Michigan are all located on a large river where a good supply of water is easily available (Fig. 11).

IMPORTANCE OF MICHIGAN BEET SUGAR IN COMMERCE

The United States imports practically no refined sugar and exports but little. From 1921 to 1923 the per capita consumption of sugar in the United States was 104.3 pounds.[18] All of the refined beet sugar from the Michigan factories enters into domestic commerce for local consumption. The average yearly production of sugar in the United States for the period 1919–1924 amounted to 878,425 short tons of beet and 211,135 short tons of cane (excluding possessions). Michigan produced for the home market an average of 121,986 tons (13.9 per cent) of the total beet sugar produced in the country. The Michigan production amounts to 1.8 per cent of the world production of beet sugar. The steady to increasing demand for sugar in the United States gives stability to the sugar market, and consequently, the Michigan sugar companies are able to contract with the farmers for beets in advance at a definite price.

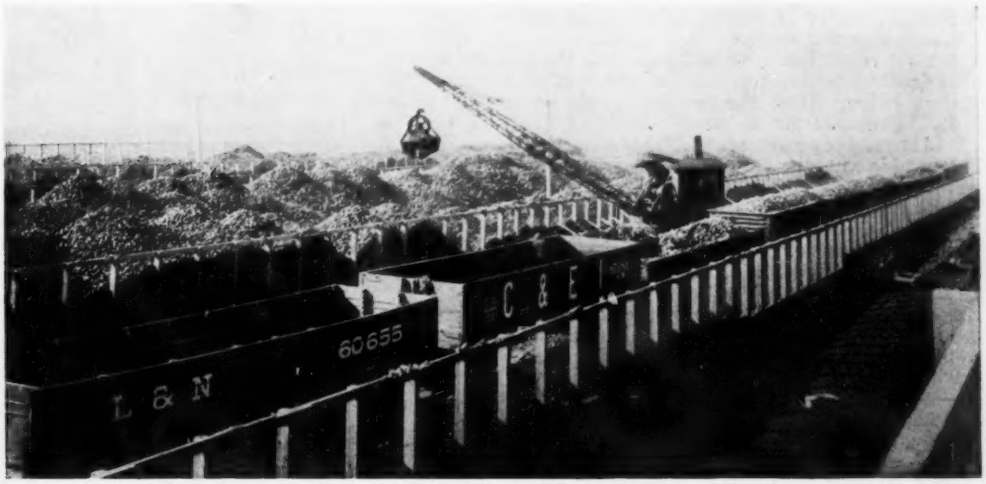

FIGURE 19.—Unloading sugar beets at the factory with a steam scoop. The beets are placed in huge bins from which they are carried to the factory in flumes. Some factories dump the beets into the bins from the gondola through the use of overhead tracks. (Courtesy of F. L. Crawford, Secretary of Michigan Sugar Co., Detroit, Mich.)

It must be remembered that the sugar of commerce is sucrose. Beet sugar and cane sugar are both sucrose.[19] The percentage of sucrose (in grams) in the ripe juice of sugar cane is 14 to 26, in sugar beets 10 to 26, millet sap 10 to 18, maple sap 4 to 5, melons 8, peach fruit 7, and orange fruit 4. As a matter of fact, the terms

[18] U. S. Department of Agriculture, Year Book, 1924, p. 802.

[19] John E. Mackenzie, "The Sugars and Their Simple Derivatives," 1914, pp. 8–42.

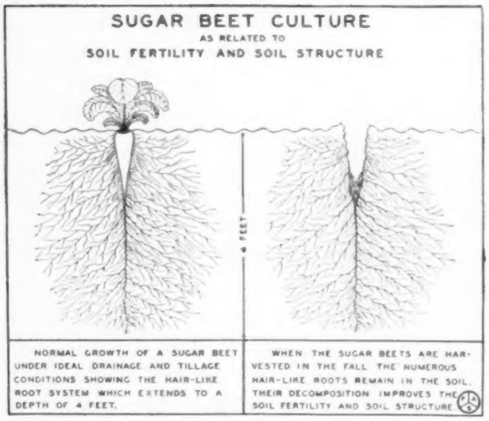

FIGURE 20.—Of all root crops, the beet has the greatest quantity of fibrous roots, which range from the size of a needle to that of a slate pencil, reach out in all directions and penetrate the soil to a depth of four feet or more in search of food and moisture. With the removal of the main root, the mass of fibrous roots is broken off and left in the soil to an average weight of a ton to the acre, and in rotting, they not only deposit humus in the lower strata of soil, but leave minute channels through which the soil becomes thoroughly aerated and hence fertile. The winter moisture fills the root interstices and creates a vast underground reservoir with which to nourish the roots of succeeding crops. The roots of subsequent crops follow the interstices left by the fibrous beet roots and hence draw moisture and nutriment from two or three times the depth of soil formerly reached.

beet sugar and cane sugar are nothing more than trade names for the same product. Chemists have shown that there is no difference. If the product has not been carefully refined, that is, if the filtration, decolorization, washing, and draining process has not been thoroughly completed, the sugar crystals are apt to show discolorization, or perhaps a scum will appear when melted into a sirup. The size of the crystal is only a physical property. The Michigan Sugar Company makes sugar with three grades of crystals, coarse, medium, and fine to meet the demand of different kinds of trade. Some think coarse sugar better, others fine. Many people entertain the idea that there is a difference between beet sugar and cane sugar. There is no difference. Sucrose is sucrose no matter if extracted from a cane, a beet, or a fruit, and sucrose crystalizes in the monoclinic system to form sugar, cane, beet, or whatnot, the sugar of commerce.[20] When washed free of foreign substances, the crystals are perfectly transparent and colorless. Beet sugar manufacturers challenge any chemist to show that there is a difference between beet and cane sugar. The term cane sugar was originated from the historical fact that sugar was first prepared from cane.

The fact that sucrose, or beet sugar, or cane sugar, is a standard product, if carefully refined, is coming to be more and more understood by the sugar users of the United States. Candy factories, ice cream factories, bakeries, preserving establishments, and the like, have become aware that there is no difference between beet and cane sugar, and recently such concerns have been buying from the Michigan Sugar Company, and other beet sugar companies, hundreds of carloads of beet sugar—the home product. Hence, these food manufacturing concerns are boosting Michigan agriculture. Before the war the consumption of beet sugar was greater than the consumption of cane. The average World's production of sugar (1910–1912) shows 8,490,000 tons of beet, and 7,646,000 tons of cane. The disturbances in Europe resulting from the World War have greatly lowered the production of beet sugar, but there is no doubt but what the sugar beet will again play a leading rôle in the production of the World's sugar supply in the near future.

RELATION TO OTHER AREAL INDUSTRIES

The sugar beet culture of Michigan is a valuable asset to the Dairy Region in which the industry is areally located. Beet pulp is one of the leading foods used in balanced rations for dairy cattle. The sugar companies have spent thou-

FIGURE 21.—The great bulk of Michigan sugar beets are grown in the Saginaw Valley Lowland, the margin of the Thumb Upland, and the Erie Lowland. This map shows the actual area in which the bulk of the beet crop is produced together with the area containing extensive bodies of favorable sugar beet soils where some sugar beets are produced, but where the industry can be greatly expanded as an asset on the farm balance sheet.

[20] Y. Nikaido, "Beet Sugar Making and Its Chemical Control," 1909, pp. 91–92.

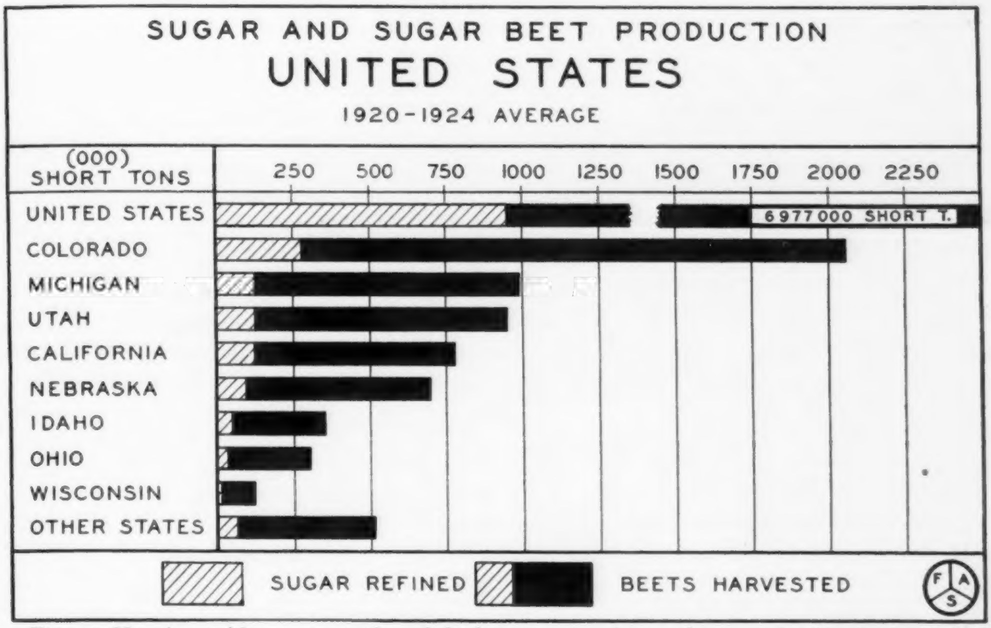

FIGURE 22.—A graphic representation of the beet sugar and sugar beet production in the United States. Computing the five-year average from 1920 to 1925, Michigan assumes second place as a producer of refined beet sugar and total beet tonnage with Utah and California closely following in the matter of refined sugar, but with much less tonnage. Irrigated beets have a greater sugar content.

sands of dollars to facilitate the drying of the pulp so that it will be fit for stock food, and thus be returned in large part to the farms in manure.

BY-PRODUCTS FOR LIVE STOCK

Beet tops and leaves furnish excellent feed for live stock. Some farmers leave the tops on the ground and pasture them with sheep and cattle. The animals are placed in the field for short intervals until they become accustomed to the new food. Other farmers ensile the tops and leaves by burying them in trenches between layers of straw.[21] They are then used as needed in balanced rations for dairy cattle and fattening steers. In many instances the tops are plowed under for fertilizer.

BEET PULP AND MOLASSES RESIDUE

Beet pulp is a well-known stock feed among dairy farmers. The dry or moistened beet pulp is made into balanced rations with other grain feeds, and fed to dairy cattle with excellent results. The pulp from the factories is generally consumed at dairy farms in and about the beet districts of Michigan as well as in other states. About one-twentieth of the pulp output from the Alma factory of the Michigan Sugar Company is marketed in Michigan, and the remainder is sold in New York, New England States, Pennsylvania, Virginia, West Virginia, and occasionally Florida.

Molasses residue is used for stock food as well as for making alcohol. The molasses is often mixed with alfalfa meal for dairy cattle. Obviously, the sugar beet industry is a valuable asset to the Dairy Region of Michigan.

RESIDUE FOR FERTILIZER

The lime residue from the manufacturing process is often used for fertilizer. The lime residue from the filters, after washing, is conveyed out of the factory to the dump. It contains organic matter, phosphate and potash, carbonate of lime, and about 2 per cent of sugar which is the greatest loss in the process of manufacture. This lime is obtained by

[21] J. F. Cox and E. B. Hill, "Sugar Beet Growing in Michigan," Special Bulletin No. 106, East Lansing, Mich., pp. 20, 21.

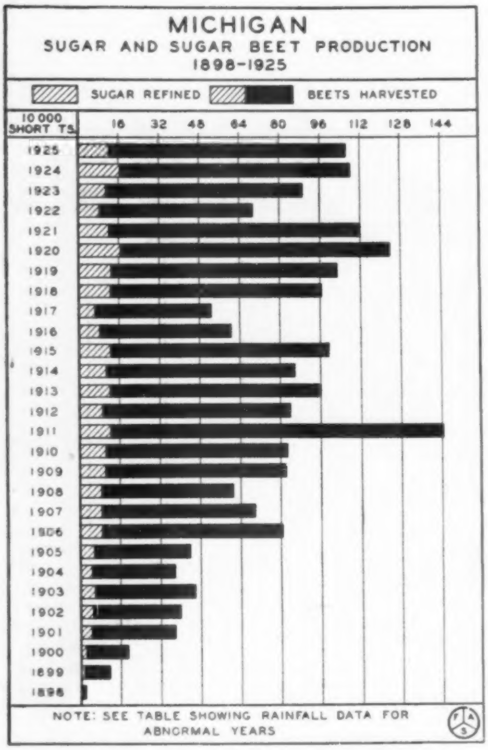

FIGURE 23.—A graphic history of beet sugar and sugar beet production in Michigan. See Table III for climatic data relating to abnormal production in 1908, 1911, and 1920. The low production in 1916, 1917, and 1922 was not due to climatic conditions, but, instead, to the higher prices paid for other agricultural commodities which were in great demand in Europe. The fall of 1911 was very wet and cool. Consequently a very large tonnage with low sugar content.

the farmers for the hauling. Little is used from the Carrollton and Bay City factories because the surrounding lands do not need lime.

CONCLUSIONS

A great deal of potential sugar beet land exists in Michigan (Fig. 21). According to a recent survey of the Thumb District it has been found that a great many acres of farm land is good or fair for sugar beet culture, and could be planted to beets without changing greatly the type or method of farming. A number of records taken in 1922 from farms near Alma, Bay City, Caro, Owosso, and Sebewaing show that a total of 5,795 acres were planted to sugar beets on the farms investigated, and that a total of 16,940 acres could be planted without changing the farm method. The acreage on these farms which no doubt gives us a fairly accurate representation of conditions in the Thumb District, and elsewhere, can be increased by 11,145 acres, or 192 per cent of the present acre production.[22] Besides this possibility there are thousands of acres of land in the south half of the Southern Peninsula with favorable soil types which can produce beets when geographic and economic conditions become more favorable. This is true with small areas of the Northern Peninsula as well.

Several geographic and economic factors have held further expansion of the sugar beet industry in check during the past 16 years. Limited amount of land suitable for crops, length of haul to the factory or loading station, necessity for proper crop rotation, interference of plant pests, presence of bad roads, and lack of adequate drainage are some of the geographic handicaps. Amount of available labor, poor distribution of labor, and lack of capital are economic difficulties. With these geographic and economic problems solved, Michigan will be able to treble her beet sugar production, but much of this added production will have to come at the expense of other crops, which are not at present yielding the farmer a legitimate return on his investment. It is quite true that the sugar beet industry of Michigan has made remarkable advancement during the thirty-six years of its existence. With the favorable natural geographic conditions harmonized to meet the demands of the scientific performance of sugar beet culture, with the geographic and economic problems resulting from maladjustment to natural conditions duly solved, and with the education of more farmers to the scientific principles of sugar beet growing, the state of Michigan can, and will, assume a greater responsibility in the production of sugar to supplement the demands of an increasing population.

[22] U. S. Tariff Commission, "Costs of Producing Sugar Beets," Part I, Michigan, 1923, p. 79.

THE COTTON INDUSTRY OF PERU *

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and
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ALTHOUGH the cotton industry of Peru dates back to an era before the Spanish occupation, perhaps before the establishment of the picturesque kingdom of the Incas, it has become important commercially only during the last thirty years. The exports of cotton increased from 10 million pounds in 1896 to 90 million in 1924; they now amount in value to 26 per cent of the total exports (average 1921–1925) ranking next to sugar. In addition to the export movement more than 12,500 bales are consumed annually by domestic mills.

The cotton industry is of basic importance to the entire economic life of the Republic. Cotton, unlike sugar cane, is the principal money crop of the small and medium-sized properties along most of the Peruvian coast. The industry is almost entirely under the guidance and ownership of Peruvians.

THE DEVELOPMENT OF THE INDUSTRY

The origin of the Peruvian cotton industry dates back to dim historical times. Cotton was the principal fiber of the ancient peoples of this region and its conversion into yarns and fabrics dominated their technique. Two varieties of cotton were produced: one with a fine high-grade lint of fair length averaging about 1¼ to 1½ inches, and the other a short uneven reddish brown type.

During the hectic days which followed the advent of Pizarro and his successors, the cultivation of cotton was almost abandoned, to be revived in a more or less haphazard way in colonial days. Some efforts were then made to revive the spinning industry, but with indifferent success. Even after Peru achieved her independence, the cultivation of cotton remained at a standstill until the outbreak of the Civil War in the United States, which almost eliminated the cotton-producing Confederate States. Then new varieties of cotton were introduced into Peru, but no one conscientiously attempted scientific cultivation. Throughout the past century, or until the last quarter of it, the Peruvian plantations suffered from lack of available labor, since for many decades neither the Spanish conquerors nor the independent Peruvians had any idea of incorporating the indigenous labor into their new agricultural system.

A little later came the economic crisis of 1875, followed by the War of the Pacific in 1879–1884. Many years later the slow work of rebuilding the national economic structure began, and with it came a development of the cotton industry. And only then was there attempted a sane solution of the labor question through making use of the almost unlimited quantity of Indian

* *Editorial Note.*—This article constitutes SCIENTIFIC CONTRIBUTIONS NO. 9, TROPICAL PLANT RESEARCH FOUNDATION, WASHINGTON, D. C.

A reconnaissance survey of the West Coast of Peru was undertaken by the Tropical Plant Research Foundation for the National Agrarian Society of Lima, and carried out during the period January to June, 1926, by Mr. Arthur H. Rosenfeld. The purpose of this survey was to secure information to be used as a basis for recommendations concerning the organization of an experiment station for the sugar and cotton industries. A report on the sugar cane industry has been published ("Facts About Sugar," 21: 1180–83, 1204–07, 1234–37, Dec. 11, 18, and 25, 1926). The accompanying article includes, with information gathered by Mr. Rosenfeld, data procured by Dr. Clarence F. Jones of Clark University, who visited the region in 1925.

labor. Another drawback to the development of the coastal plantations of that epoch was that most of them were in the hands of rich families who entrusted the management of these properties to the more useless sons who had, perhaps, made a failure in the university or in political life, with the result that the country so vitally dependent upon her agricultural activities had those agricultural interests entrusted to the most inept hands. Agriculture was conducted along routine lines, the methods of cultivation employed being based not on any intelligent observation or experience, but simply on the results of the initiative of some negro peon or foreman. Even the island guano which the Incas and their predecessors had used to such wonderful advantage was now unused and the lands began to show the results of exhaustion and improper cultivation.

It was only in the present century that the real renaissance of the Peruvian cotton industry began. Even from 1900 to 1907 Peru's annual exports of cotton averaged only about 32,000 bales, but in 1908 they jumped to twice that amount. Then, too, the first decade of our century was marked by the abandonment of sugar cultivation in several of the more southerly valleys and the conversion of these former cane valleys into the principal cotton-producing portions of the Republic. This movement, incidentally, of changing from cane to cotton has continued until the present day, particularly in the Cañete, Rimac, and Carabayllo valleys close to Lima.

Further impetus was given to cotton growing by the high prices prevailing during the World War, when planters put all available land under the fleecy staple; exports increased from 50 million pounds in 1914 to 95 million pounds in 1923, the peak in the export movement (Fig. 1). The development of the industry since the War of the Pacific has given Peru commercial stability. It brought prosperity to the coastal valleys and elevated the standards of living of the laboring classes (Fig. 2). Prosperity

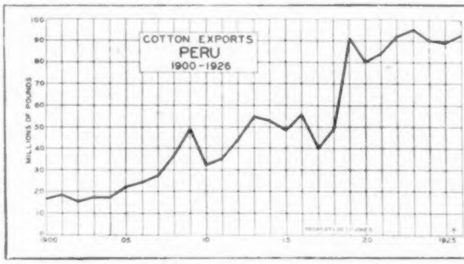

FIGURE 1.—The exports of cotton from Peru increased from 17 million pounds in 1900 to 55 million in 1913. After a temporary setback during the World War, the exports rose to 90 million in 1919. In 1926, the exports rose to 93 million pounds. The growth in the cotton industry along with that of sugar has given Peru commercial stability.

in the industry serves as a trade index for the entire country.

DISTRIBUTION OF COTTON

Although small quantities of cotton are grown on the eastern side of the Andes, practically the entire crop comes from the irrigated valleys of the coastal desert, which is both agriculturally and socially by far the most important part of Peru. Here lie the great sugar and vast cotton estates which produce more than half of the Peruvian exports.

In the coastal area live practically all of the wealthy and influential Peruvian families, most of them having magnificent palaces in the capital and country homes on an estate in one of the irrigated valleys, although a few spend part of their time on sheep or cattle ranches in the highlands. In fact, outside of the thousand square miles or so of cultivated land contained in this strip, less cultivated land than exists in the island of Porto Rico, Peru supplies little to the outside world, except her mineral exports.

Twenty-three of the twenty-five cotton districts of Peru lie along this coastal strip, the two outside ones, the Iquitos region in the Amazonas section and the Huánacuo district almost due west of Casma, producing but small quantities. These coastal valleys extend from Tumbes, at the northern extremity of the country and on the Ecuadorian border, to Ilo, south of the port of Mollendo and

just north of the much discussed Tacna-Arica area (Fig. 3). They include 280,000 acres of irrigated land devoted to cotton culture;[1] the most important cotton-producing districts lie between Supe, to the north of Callao, and Pisco, the largest cotton-producing valley of the country; Tambo de Mora, the port for the Chincha Valley, is the second cotton port, the third being Paita, the outlet for the Piura and Chira valleys located far to the north of the main producing area.[2]

SOILS

The thread-like flood plains constitute the only agricultural lands of the Peruvian coast; on them grows nearly all of the Peruvian cotton crop.

These cotton valley soils, generally quite deep, possess excellent texture, and good natural drainage, owing to the fact that most of them are superimposed on permeable strata of sand or gravel. In general, the soils are easy to work and their physical condition, where tillage is difficult, can always be improved by irrigation. This advantage of easy and cheap drainage and of usually abundant supplies of irrigation water goes far toward solving the alkali problem, which would otherwise be rather serious in many of the cotton valleys.

The physical and chemical composition of these soils varies with the nature of the rocks over which the streams forming them have flowed, the slope of the rivers, and the formed land. The proportions of sand and clay are variable in the different valleys and the cohesion and permeability of the soil vary also within wide limits. All classes of soils occur in the several valleys, from compact and humid ones of almost pure clay, through loams and sandy loams to almost pure sand. The more gravelly, stony, and least moisture-retaining soils lie in the upper parts of the valleys, while the more alkaline ones are encountered in the lower sections, owing to less efficient natural drainage and to the accumulation of alkali salts in the waters of filtration. The thickness of the top soil is greatest in the lower parts of the valleys where it occasionally reaches several feet. The subsoils vary both in physical and chemical conditions; the stony, gravelly, and sandy subsoils show well-drained and porous top soils above them, whereas the more impermeable subsoils, particularly in the case of shallow top

[1] The average area in cotton in Peru in 1914–1915 to 1918–1919 was 163,000 acres, that in 1921–1922 to 1925–1926, 284,000 acres. The acreage in 1924–1925 reached 301,000. *Foreign Crops and Markets*, Volume 14, March 7, 1927, No. 10, p. 301. United States Department of Agriculture, Washington.

[2] COTTON AREAS AND PRODUCTION PER HECTARE BY VALLEYS, 1923–1924.

Departments and Valleys	*Area of Estates Hectares*	*Area Planted to Cotton Hectares*	*Production per Hectare in Metric Tons*
Piura			
La Chira	......	9,021	0.591
Piura	......	14,715	0.437
Lambayeque			
Lambayeque y Chiclayo.	23,477	423	0.338
La Libertad			
Jequetepeque	18,935	872	0.786
Moche	963	143	0.200
Virú y Chao	1,500	140	0.875
Chicama	900	228	0.828
Ancash			
Santa y Chimbote	12,086	1,322	1.411
Nepeña	11,817	1,264	1.044
Casma	8,666	1,009	0.986
Huarmey	3,750	642	1.532
Lima			
Pativilca	11,848	4,662	1.324
Barranca	3,278	2,710	1.578
Supe	2,060	2,002	1.384
Huaura y Sayán	5,391	2,776	1.638
Campiña de Huacho	7,805	3,035	1.077
Chancay	12,965	8,088	1.651
Carabayllo y Quebrada de Yangas	7,981	2,676	1.210
Bocanegra y Piedra Liza	3,536	1,084	1.216
Lurigancho	2,733	1,668	1.337
Huático	1,081	495	1.211
Magdalena y La Legua	1,446	472	1.247
Ate (Alto y Bajo)	3,431	1,562	1.298
Sureo	4,876	2,038	1.271
Lurín y Pachacamac	5,554	1,844	1.201
Cañete	13,126	6,427	1.544
Lunahuaná	1,675	620	1.640
Ica			
Chincha	......	14,031	1.206
Pisco	......	6,691	1.183
Ica	......	8,683	1.145
Palpa y Nazca	......	3,624	1.089
Arequipa			
Ocoña	425	112	1.540
Camaná	......	1,127	1.452
Majes	1,178	435	1.533
Tambo	......	355	1.336
Moquegua			
Moquegua	......	206	1.708
Tacna			
Locumba	......	175	1.488
Sama y Habaya	......	203	0.913
Loreto			
(Huallaga, Ucayali, Amazonas y Marañón)	......	5,754	0.500
Huánuco			
Huánuco	......	192	0.800
Junín			
Chanchamayo	......	35	0.920
Total and general average	......	113,560	1.092

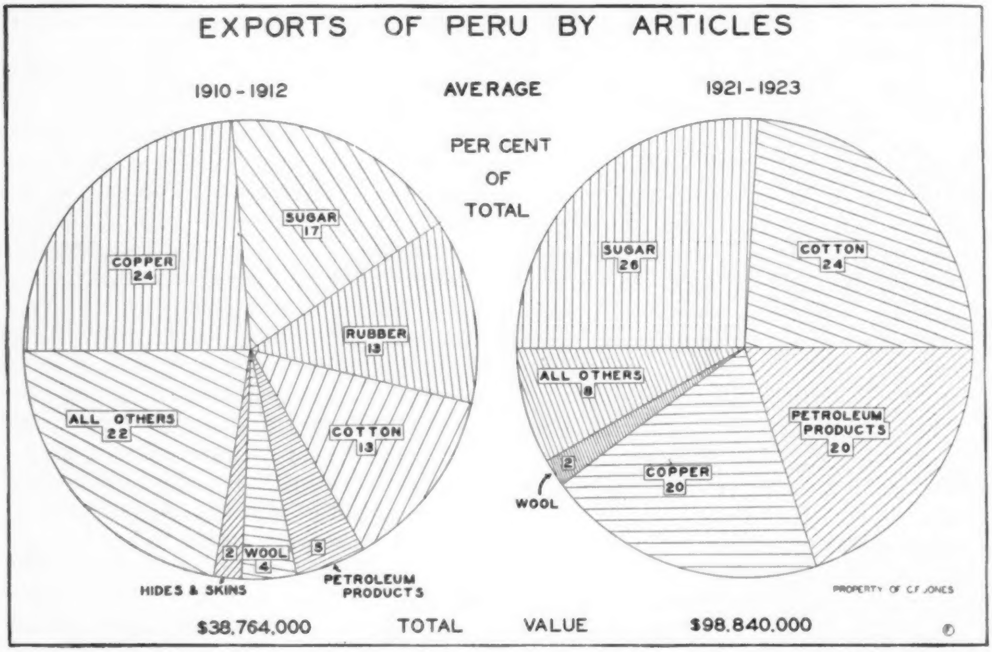

FIGURE 2.—The value of cotton exported from Peru increased from 13 per cent of the total export trade before the World War to 24 per cent in 1921–1923; the average of 1921–1925 equalled that of sugar, 26 per cent of the total. These two products from the irrigated coastal valleys now supply more than half the total export trade of this Republic so long noted for its great mineral wealth.

soils, show the more humid and poorer drained types superimposed upon them.[3]

CLIMATE

In this practically rainless desert, the climate in several ways favors the output of high yields of good-grade cotton, in spite of the fact that the lack of rainfall restricts the production of cotton to those areas which can be irrigated. No hail injures the growing boll, no rain discolors the ripening fiber, and no frosts arrest the development of the plant.[4] The relatively high temperature throughout the year, the large amount of sunshine, and the proper application of water from the mountain streams to the heavily fertilized alluvial soils afford optimum conditions for the growth of the plant (Fig. 4).

VARIETIES OF COTTON

Five principal varieties of cotton are grown in Peru; each of these has several grades.[5]

Full-Rough (Áspero)

The famous "Peruvian Full-Rough," the best type of original native cotton, grows only in the Department of Piura,

[3] J. A. Lavalle y Garcias, *Los Carácteres Agrológicos de las Tierras Cultivadas en la Costa Del Perú, Lima*, 1918; A. H. Rosenfeld, "The Sugar Industry of Peru," *Tropical Research Foundation, Scientific Contribution No. 6*, pp. 8–11, Washington, 1926.

[4] Rosenfeld, *loc. cit.*, pp. 7–9, contains a detailed discussion of the climate and tables of mean precipitation and mean temperature of Piura, Chiclayo, Lima, Callao, and Mollendo.

[5] PRODUCTION OF COTTON BY VARIETIES AND VALLEYS IN 1923

Valleys	*Full-Rough*	*Semi-Rough*	*Mitafifi*	*Tangüis*	*Egipto*	*Ginned Cotton M.T.*	*Cotton Seed M.T.*
La Chira	610	......	720	50	560	1,941	3,392
Piura	2,037	......	110	....	248	2,396	4,041
Lambayeque	......	27	20	....	....	48	95
Guadalupe y Jequetepeque	......	......	160	141	2	305	484
Moche	......	......	16	15	30	62	109
Virú y Chao	......	......	14	10	19	44	78
Chicama	......	......	61	1	7	70	118

in the extreme north. Its rough, crinkly fiber, averaging $1\frac{1}{4}$ inches in length, is adapted to mixing with wool in textile manufacture. The plant, which grows to a height of 9 to 12 feet and has the appearance of a small tree, yields four or five good crops from one planting. Although the tree lives for fifteen to eighteen years, the decreasing yields after the fourth or fifth crop make replanting advisable. There are two main harvest seasons with this variety in Piura, the first, July to September, and the second, late December to March.

Semi-Rough (Semi-Áspero)

Semi-rough, a distinct variety not up to the standard of full-rough and possibly of different origin, gives a low yield and a semi-rough, crinkly fiber about $1\frac{1}{8}$ inches in length. The methods employed in producing it are similar to those of the Full-rough.

Suave or Egipto

Suave or *Egipto*, a variety imported from the United States shortly after the Civil War, has a smooth fiber from $1\frac{1}{16}$ to $1\frac{1}{8}$ inches in length and yields one stubble crop after the plant crop in the Chincha Valley, the chief area of production. Although this type was grown to a considerable extent in most of the cotton valleys and still constitutes a fair percentage of the total crop, it is being replaced rapidly by *Tangüis*.

Tangüis

Tangüis, the most important cotton variety in Peru, is rapidly increasing its range year by year. It derived its name from its producer, Mr. Fermín Tangüis, a prominent planter of Pisco. This variety was obtained from a selection resulting from a cross between two varieties not certainly identified, while Mr. Tangüis was attempting to obtain a wilt-resistant cotton during the severe outbreak of this trouble some twenty years ago. It produces well in practically any type of Peruvian soil and does fairly well even in the more saline ones,

Valleys	*Full-Rough*	*Semi-Rough*	*Mitafifi*	*Tangüis*	*Egipto*	*Ginned Cotton M.T.*	*Cotton Seed M.T.*
Santa y Chimbote	......	......	439	167	16	622	1,242
Nepeña	......	......	220	219	....	439	879
Casma	......	......	33	100	197	332	663
Huarmey	......	......	121	22	6	345	637
Pativilca	......	......	1,467	641	216	2,329	3,843
Barranca	......	......	1,181	282	53	1,518	2,758
Supe	......	......	868	....	69	938	1,832
Huaura y Sayan	......	......	1,320	328	70	1,719	2,827
Campiña de Huacho	......	......	....	1,029	144	1,173	2,097
Chancay	......	......	908	3,295	902	5,106	8,247
Carabayllo y Quebrada de Yangas	......	......	135	742	343	1,221	2,016
Bocanegra y Piedra Liza	......	......	102	223	161	488	829
Lurigancho	......	......	74	451	286	812	1,417
Huática	......	......	97	67	57	222	376
Magdalena y La Legua	......	......	46	109	57	213	375
Ate (Alto y Bajo)	......	......	....	493	200	768	1,258
Surco	......	......	128	698	171	998	1,591
Lurín y Pachacamac	......	......	98	507	220	826	1,388
Cañete	......	......	67	3,153	620	3,841	6,082
Lunahuaná	......	......	59	284	43	387	628
Chincha	......	......	....	1,853	4,146	6,000	10,915
Pisco	......	3	1	2,481	564	3,051	4,860
Ica	......	60	25	3,065	684	3,836	6,101
Palpa y Nazca	......	388	....	768	357	1,514	2,431
Ocoña	......	......	....	69	....	69	103
Camaná	......	......	8	154	410	573	1,062
Majes	......	......	16	241	25	283	383
Tambo	......	......	130	15	30	175	298
Moquegua	......	......	....	140	....	140	211
Locumba	......	68	....	....	....	68	189
Sama y Llabaya	......	74	....	....	....	74	111
Loreto:							
Huallaga	......	629	....	....	....	629	1,259
Ucayali	......	282	....	....	....	282	565
Amazonas	......	32	....	....	....	32	65
Marañón	......	13	....	....	....	13	26
Huánuco	61	......	....	....	....	61	92
Chanchamayo	......	12	....	....	....	12	19
Total	2,709	1,592	8,732	21,831	10,930	45,996	78,013

Estadística de la Producción Algodonera en el Perú, *Ministerio del Fomento, Dirección de Agricultura y Ganadería* (*Annual*) Lima.

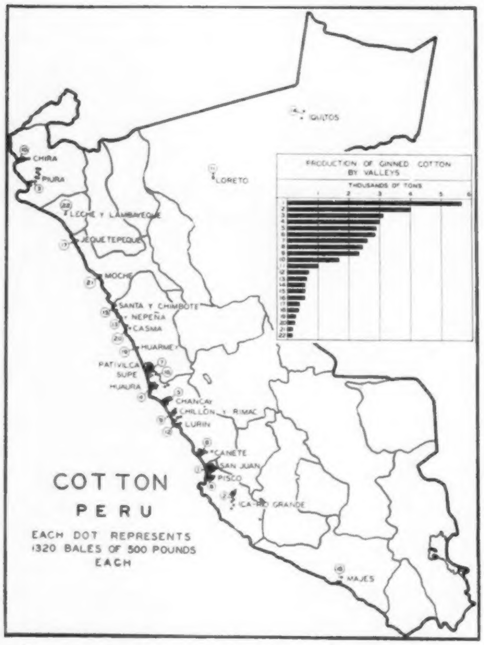

FIGURE 3.—Practically the entire cotton crop of Peru comes from three distinct districts—the Chira-Piura in the north, from Chinbote to Lurin in the center, and Cañete to Ica in the south—in the irrigated coastal valleys. (Statistics four-year average 1916–1917, 1918–1919, 1920–1921, 1922–1923; *Statistical Abstract of Peru* 1919, 1920, 1923, 1924, Department of the Treasury and Commerce, Lima; *Estadistica de la Produccion en la Peru 1920 y 1921*, Ministerio de Fomento, Lima, 1924; *Foreign Crops and Markets*, March 22, 1926, Department of Agriculture, Washington.

although the *Suave* is generally considered to be the type best adapted to such soils. *Tangüis* has the great advantage of producing three to four stubble crops on a commercial basis, the yield not falling off in second and third year stubble so rapidly as with Egyptian or *Mitafifi* and always gins out far better, producing more than 40 per cent lint against about 33 for the *Egipto*. It sticks in the boll a long time after opening and can be picked, therefore, more leisurely without running the risk of serious losses by dropping. The white and moderately smooth fiber averages about 1⅜ inches. *Tangüis* gives a high yield, 20 to 28 per cent greater than any other variety. In a recent year, it formed 60 per cent of the entire Peruvian crop and its cultivation is rapidly increasing. In Pisco Valley, *Tangüis* is the only variety grown. The "Superfine" grade of *Tangüis* now brings the highest price of all Peruvian cottons, the next grades being the "Good Fair" and "Fair." Unfortunately the type is not fixed.

Mitafifi

Mitafifi is the genuine Egyptian type so widely grown in the Supe, Pativilca, Barranca, Chancay, and Huacho valleys, north of Lima. The first three valleys named produce hardly anything else, except on the lower lands in the Chancay valley, where *Egipto* is planted. The fiber of *Mitafifi* is cream colored, smooth and very silky, averaging about 1¼ inches in length; it is the variety most in demand for the manufacture of automobile tires. Usually only one plant and one stubble crop are produced from a planting.

Other Varieties

Small quantities of Sea Island cotton are grown in some of the valleys, particularly in Supe. *Huanuco* cotton, a variety similar to Brazilian cotton, is grown in the Huanuco Valley. Cotton grows wild in some of the interior sections, where it is utilized by the Indians in weaving homespun garments.

PREPARATION OF LAND FOR COTTON

On the whole, the land for cotton is well prepared. On the larger estates, after the land is thoroughly cleaned, it is plowed with the Fowler stationary steam engines, which pull the plows along by means of a cable rolled on a drum underneath the locomotive. These engines may be placed as far apart as six hundred yards and do remarkably efficient work (Fig. 5). A set of them costs about $25,000, but they are well constructed, simple in operation, and durable.

Three deep plowings, with the stationary engines, tractors, or bull plows, followed by harrows and a cross harrowing, leave the fields in an excellent con-

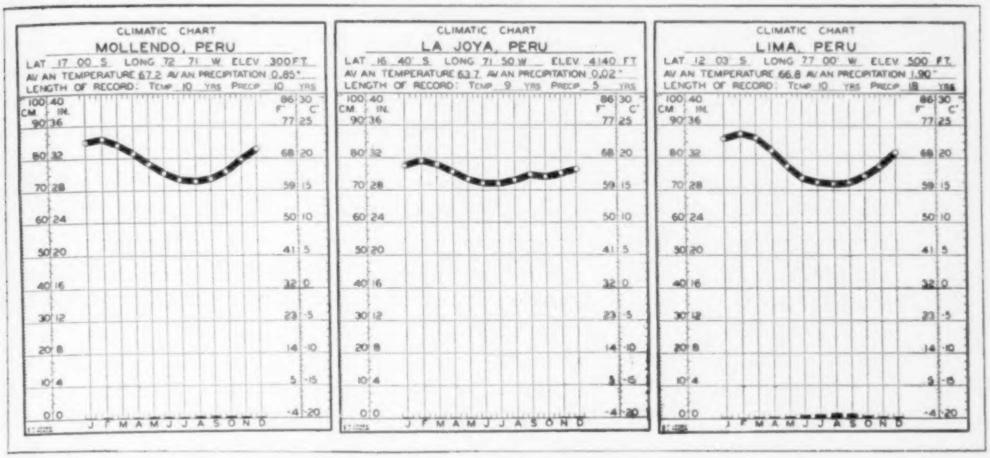

FIGURE 4.—The uniformly high temperatures, the large amount of sunshine, and no rain to discolor the ripening fibers, favor the growth of an excellent quality cotton in the Peruvian coastal desert.

dition for planting. Where the land is too hard and dry for the best work, the application of the proper quantity of water puts it in a good condition for working.

THE RATOONING OF COTTON

In Peru first, second, or third ratoons are spoken of just as commonly on the cotton plantations as on the cane *haciendas*. With all varieties at least one stubble crop can be obtained that will compensate for its reduced yield by the correspondingly reduced cost of production, while *Suave* generally gives two stubble crops. With proper fertilization, *Tangüis* seems to increase its yield as first-year stubble; much third-year stubble is cultivated profitably in the Pisco and Cañete valleys.

After each crop, the plants which have been cut back to the ground with a sharp *machete* sprout from the roots, and are cultivated just as stubble cane would be. Without the expense of preparing and planting the land anew, the cost of producing stubble crops is low. After two to four crops, the yield drops to such an extent that it pays better to plow the crop up and replant.

FERTILIZER PRACTICE

Almost the only fertilizer used on cotton in Peru is guano, which contains about 12½ per cent nitrogen, 8 per cent to 9 per cent phosphoric acid and 2 per cent of potash. The efficient distribution of the guano over Peru through the Guano Administration Company places this valuable fertilizer at the disposal of the planters at prices based upon the chemical analysis of the product. From 200 to 250 pounds of guano per acre are applied each year. It is applied first when the plant is about four inches high—a handful being placed in a small hole near the plant—and then at regular intervals during the growth of the plant.

IRRIGATION

The rainfall and the melting snow and ice of the Andes supply the life-giving waters of the cotton fields of the coastal valleys. Yet only a small portion of the water of this natural reservoir goes to the fertile agricultural lands, for during the flood season millions of cubic feet in raging torrents flow unutilized to the Pacific.

The amount of cultivated land is limited only by the quantity of irrigation water available. The valleys of Santa and of Tambo are two exceptions to this rule, for some water generally flows into the sea the year round from the streams watering those valleys. Fortunately, abundant water and high temperatures

coincide in Peru, inducing a rapid development of cotton during the flood season.

The quantity of irrigation water applied to the cotton fields varies with the location of the valley, the type of soil, the time of the year, and the age of the fields. Each field in the highest part has the *acequia madre*, or mother ditch, from which radiate the secondary canals carrying the water to the various smaller fields, called *cuarteles*, and thence down the rows or middles. The excess water from the furrows collects at the lower end for re-use in fields at a lower level.

Several times the actually cultivated land along the Peruvian coast could be brought under cultivation were water available for irrigation; it has been estimated that the waters of the flood season, if properly stored by means of dams and reservoirs, would be sufficient to double the area cultivated. However, a 20 to 25 per cent increase in the crop land, according to the best estimates, is the greatest that can be expected for a long time.[6]

While these arid desert lands are capable of yielding large crops, it is not merely a matter of applying water to

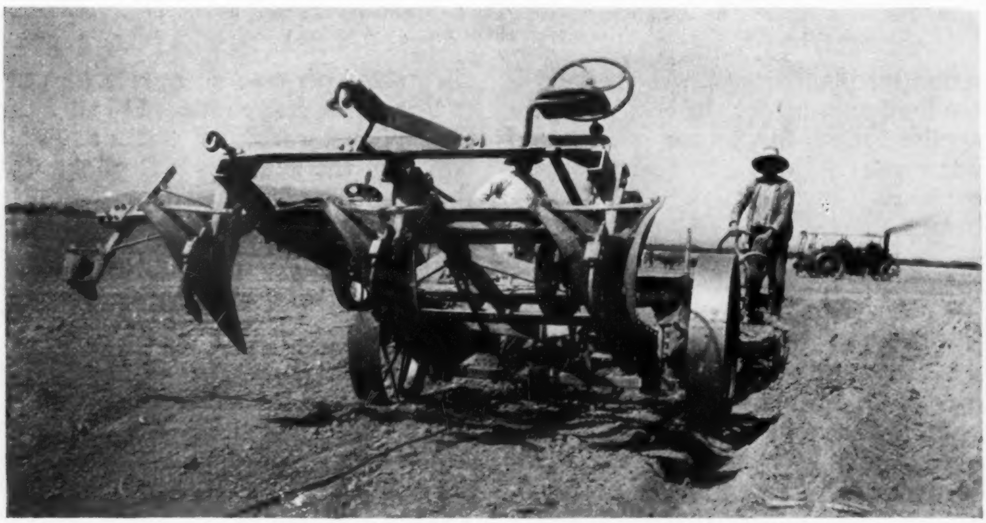

FIGURE 5.—Plowing in a coastal valley of Peru with two steam engines which pull the large plows across the field by means of a big cable rolled on a drum underneath the engine. The plows are equipped to work in either direction so that they are not turned around at the end of the field. (Photo by C. F. Jones.)

Remarkable efficiency in laying out irrigation ditches, and in directing the flow of water makes possible the irrigation of large areas of land with a small number of *peons*.

The applications of water are most frequent during the summer months, owing to great evaporation and rapid growth of the cotton. It is almost impossible to calculate the amount of water used per acre or per crop at any time or place; no plantation visited by the writers had any actual measuring device or weir.

turn them into productive lands of high quality. Some areas contain alkali, many lack organic matter, while others vary so in texture that often the light top soil washes away when water is first applied. Such lands should be divided

[6] During the last few years, a number of large irrigation projects have been started under the direction of Charles W. Sutton, an American engineer in charge of Government Irrigation Work. C. W. Sutton, "The Olmos Irrigation Works," *The West Coast Leader* (*Annual Cotton Number*), 1925, pp. 15–16; W. E. Dunn, Peru, *A Commercial and Industrial Handbook*, pp. 98–101, *Trade Promotion Series No.* 25, *Department of Commerce*, Washington, 1925.

into shallow, almost level, beds with a small furrow thrown up on the lower side to hold the water. Then they should be heavily irrigated and each of these beds turned into a little lake, allowing the silt to settle and become incorporated with the light desert soil, giving it body and a certain amount of organic matter. This process repeated many times and a liberal use of legumes in the first years of reclamation put the soil in excellent condition for good crops of high-grade cotton.

DRAINAGE

On account of the lay of the land, drainage is not a serious problem in general except on the lower, heavier lands where in some exceptional cases tile drainage gives fine results, as at the plantation — Esquival — of the Solar brothers. This estate, of more than 7,000 acres, has 5,000 in cotton; all of this except 600 acres has been reclaimed from lagoons, largely by tile drainage. Lands formerly containing alkali have been sweetened by drainage and now produce 1½ bales of *Tangüis* cotton per acre. Usually *Egipto* is planted on the more alkaline lands and poorer drained soils.

After land is first cleared and drained, it is planted with sweet potatoes, vines, yucca, beans, or corn for a couple of years to *sacar algo de la feracidad* (reduce the fertility) of these high organic content soils. Later, cotton, always carried to second stubble, and sometimes to third or fourth ratoons, is rotated with corn or alfalfa.

PLANTING AND CULTIVATING

In valleys supplied by permanent streams cotton is usually planted from September to November. In the Santa, Casma, and Huarmey valleys, planting is sometimes carried on as early as June or July. In the Piura section where *Full-Rough* or *Aspero* dominates, from March to April is considered the best planting season because at that time water is most abundant and the largest areas can be most easily irrigated. In the Chira valley, one of the few cotton valleys always having an abundance of water, some planting continues to late November. In the Chincha and Ica valleys south of Cañete planting takes place in two seasons. The first corresponds to the flood season and ranges from December to February; this cotton matures in about six months. The second planting season comes in May or June, the young plants barely managing to survive the dry season until the water comes down in December. It is then heavily irrigated and grows with sufficient rapidity to produce a crop the following May or June. As several crops are obtained from one planting in all of the valleys, it is necessary to plant only a portion of the land each year, an *hacienda* having fields in different stages of maturity.

Before planting, the land is laid off in furrows about four and one-half feet apart and irrigated. Then the seeds are planted in a small hole made by a crude spade (*lampa*) on the edge of the furrow a little above water level. From fifteen to twenty seeds, dropped in each hill, assure the survival of four or five plants. After the young plants are thinned, a ridge of dirt is thrown up to prevent actual contact of the plants with the irrigation water. A few progressive planters use mechanical cultivators to keep the ridges pulverized and clean, but most of this work in Peru is done by hand labor.

In the Santa and Patavilca valleys, where labor is scarce, cotton is planted by dropping the seed along the side of the furrow and covering with a plow. In valleys of a scant water supply, the land is completely inundated and then plowed as soon as practicable, in order to break it up thoroughly and prevent the loss of water by evaporation. In the Chincha and Ica valleys in the south, cotton is often planted according to this system in May or June with alternate rows of beans or peas. These legumes mature and are harvested, often paying the whole expense of cultivating the

field, while the cotton remains rather stunted until it can be irrigated in the December flood season, after which it grows to rapid maturity.

The preceding methods of planting apply particularly to *Tangüis*, *Smooth*, and *Mitafifi* varieties. *Full-Rough* is planted in holes along the edges of actual ditches some twelve to fifteen feet apart. The distance between plants is about the same as between the ditches; the branches of these cotton trees require considerable room. The plants need little attention after they attain some size, as they are extremely hardy. *Full-Rough* begins to produce lightly in about eight to nine months, but full crops do not come on until the second year. *Semi-Rough* is handled in about the same manner.

Tending the first crop of cotton consists chiefly in keeping the ridges clean and in proper irrigation. Little mechanical cultivation is possible owing to the number of irrigation and drainage ditches. The cultivation of *ratoons*, after the old stalks have been cut a few inches above the ground with a sharp *machete* and removed, is similar to the plant crop. *Full-Rough* and *Semi-Rough*, of course, are not cut down in this manner but continue to bear for several years with practically no attention except the application of irrigation water, although the upper branches may be pruned in order to improve the yield.

FIGURE 6.—A field of *Tangüis* cotton in the Cañete Valley, Peru, March, 1926. To this new variety of cotton, Peru owes much of its importance as a cotton exporting country (see Fig. 9). (Photo by A. H. Rosenfeld.)

HARVESTING PERIODS

As with the planting seasons, the Peruvian cotton harvesting seasons are neither sharply defined nor uniform (Fig. 6). During practically every month of the year, picking will be in progress in some locality; this gives a rather uniform flow of cotton in world commercial channels. The main harvesting season, however, is from April to May, the fall and early winter months, although in some sections picking commences as early as March. *Full-Rough* in the Piura section has its first picking in July and August and the second from January to March. In the valleys growing the *Semi-Rough* there is also a second picking from October to December. In the south *Egipto* is harvested from May to July, and *Tangüis* and *Mitafifi* about a month later.

GINS AND COTTON MILLS

Peruvian cotton is carefully sorted by women and children before going through the gins, because of stained cotton in most of the valleys growing *Tangüis*, *Suave*, and *Mitafifi*, and of colored fiber characteristic of the *Full-Rough* cotton in the Piura section. The *patios*, where cotton is dried and sorted, accompany all Peruvian ginning plants; uncovered bins provide storage for the various classes of sorted cotton, as in this desert climate shelter is not necessary.

As cotton production is Peru is profitable only on a large scale, most of the *haciendados* find it convenient to own their own gins; few public gins exist in the country. Also rugged relief and lack of good roads make it more practicable to gin cotton near the source of production. However, an English firm has several public gins in the Piura, Lima, and Pisco districts; in Tambo (near Mollendo) is the largest public gin in Peru.

About 125 to 140 gins have been

operating during the last few years. Many of these consist of crude machines installed in open sheds or storerooms and have capacities of only four or five bales daily. Others quite well equipped have capacities of a hundred bales per day. Some gins are operated by water power; others by steam or oil engines. Owing to deficient motive force, the suction system is entirely replaced by hand labor. Densities of the bales average from 17 to 20 pounds per cubic foot. No cotton compresses exist in the country inasmuch as the output of each valley goes from its own port directly to foreign countries.

Two kinds of ginning machinery are used, the saw gin commonly employed in the United States being used for the *Full-Rough*, *Egipto*, and *Tangüis* cottons, and a roller gin of British manufacture for the *Mitafifi*. The slow roller gin delivers exceptionally clean lint.

Bales vary greatly in weight and size owing to the location of the plant and the transportation facilities in a particular section. Where access to the port is easy, the bales run from 425 to 500 pounds, but where burros must be depended upon for transportation, the bales usually run slightly under a hundred, although some weigh as much as 250 pounds (Fig. 7). Between these figures one may find bales of almost any weight. The bales are covered with burlap and tied with heavy wire, which serves to keep the lint clean.

FIGURE 7.—In the arid climate of the coastal valleys of Peru, cotton and fertilizer may be stored in the open for months without damage. Uncovered bins for the storage of cotton accompany all the Peruvian gins. (Courtesy of W. E. Hinds.)

INSECTS AND DISEASES

While the genuine boll weevil, *Anthonomus grandis*, is unknown in Peru, the Peruvian square weevil, *Anthonomus vestutis*, does considerable damage in the departments of Piura and Lambayeque, and takes a small annual toll in the more southern valleys. This insect constitutes the most important factor in restricting the cultivation of cotton in the Department of Lambayeque,[7] because of this it is recommended that the growing of perennial cotton in that Department be prevented, and that volunteer cotton be destroyed at certain periods of the year in order to prevent breeding. Uranga thinks that this insect will eventually cause abandonment of *Full-Rough* in the Piura district and the turning to annual types, such as *Tangüis*.[8] It is found in small numbers in all the fields of cotton in the Cañete Valley.[9]

The cotton stainer, *Dysdereus* (known locally as *Arrebiatado* or *Chinche Colorado*), identical with the cotton stainer of the United States, does great damage in the Piura district; most of the *amarillo* or yellow cotton in that department results from staining after the boll has been punctured by this insect. Fortunately, it does little damage in the southern valleys.

While Alabama *argillacea* is present and sometimes does serious damage, the Peruvian cotton worm (*Anomis sp.*), is considered the most important insect

[7] Gonzalez and Tapur, "El Departmento de Lambayeque y el Cultivo del Algondon," *La Vida Agricola*, III, 28, pp. 291–300 (1926).

[8] Urganga, Federico, "La Industria Algodonera del Perú," *West Coast Leader* (*Annual Cotton Number*), 1925, pp. 17–31.

[9] Hinds, W. E., "Informe sobre La Producción del Algodón en la valle de Cañete," *Sociedad Nacional Agraria del Peru*, Lima (1926).

enemy in the Cañete valley, while it is present everywhere in Peru. It attacks the cotton plant during a considerable portion of the growing season; it is present in abundance almost every year and frequently causes serious damage through the destruction of the entire leaf surface of many fields in a comparatively short period. It may be partially controlled by spraying with calcium arsenate (Fig. 8).

In the Pisco and Ica valleys the white scale, *Hemichionaspis miner*, (*Piojo Blanco*), has become quite serious in the past two years, causing the government to prohibit the exportation of seed from those important valleys. Forms of this scale prevalent in other valleys have not caused a large amount of damage.

For many years, by far the most injurious plant disease in Peru was the cotton wilt, but the spread of the wilt-resistant *Tangüis* cotton has relegated this wilt to the category of a secondary pest. One of the most prevalent troubles is what is commonly known as *hielo* (ice), which was formerly thought to be due to the chilling effect of cool nights on the plant, but which has not been investigated adequately. The term may refer to several different troubles and may be complicated by lack of cultivation, on account of excessive irrigation, or extreme variations in diurnal and nocturnal temperatures. They putrify the contents of the bolls, harden the fiber, and at times destroy the plant. Another insect pest which has lately been the subject of investigation is the weevil, *Gasterocercodes gossypii*.[10]

Owing chiefly to the dry sunny atmosphere, notable fungous or bacterial troubles are not found in Peruvian cotton fields.

FIGURE 8.—A "spraying gang" with knapsacks and spray pumps for combating the Peruvian cotton worm (*Anomis sp.*), the most destructive insect enemy in the Cañete Valley. Groups of men devote all their time for three months to spraying. Recently in some sections "dusting" is done by aeroplanes on a large scale. (Courtesy of W. E. Hinds.)

ECONOMICS OF PRODUCTION

The best results from cotton growing in Peru are obtained on a large scale where sufficient capital permits the proper outlays for machinery, abundant land, irrigation and drainage systems, and adequate labor.

Land Holdings

As a consequence, the smaller and less efficiently run places are being absorbed by larger ones with more resources.

[10] Klinge, Guillermo, "Informe sobre la nueva plaga del algodón en la Provincia de Pascasmayo," Boletin de la Sociedad Nacional Agraria, in *La Vida Agricola*, Vol. 4, No. 38, February, 1927.

Also, the passing of old families of estate holders, the selling of legacies, and the leasing of their properties by widows of *haciendados*, gradually centralizes the management of contiguous areas. Plantations vary in size from a hundred acres to seven thousand acres or more. Ordinarily the breaking up of huge estates would be considered in most countries a healthy economic situation, but conditions are such in Peru that the opposite process seems likely to continue for some time to come, although the advantages of this system in the long run are doubtful.

Cost of Land

The price of good cotton land in the better valleys varies from $150 to $300 per acre. Such land easily produces twice the average crop grown in the United States. The average yield of cotton in Peru for the years 1921–1922 to 1925–1926 was 334 pounds of lint per acre.[11]

Labor and Wages

Laborers usually live on the estates and are given a piece of land of their own to cultivate in addition to rations and regular wages of 58 to 75 cents for the days they work for the owners. The deficient labor supply on the coast makes it necessary for the planters to contract for Indians from the mountains during the busy season. These Indians usually are good workmen; while labor agitators have at times caused considerable trouble for both them and the plantation owners, most strikes and riots are due to dissatisfaction arising from faulty management on the part of the plantation administrators.[12] Miller,[13] a cotton expert who has been in Peru for many years, says of the Peruvian laboring class:

> "Labor troubles are more frequent and of a different nature than those of any other country. The majority of cotton pickers or workmen do not desire to improve their social position. The more they earn per day the less they work per week. Discipline of any description is rare, as with little difficulty any man, however unskilled, can secure work with practically any *hacienda* without reference or inquiry during the picking seasons. If he wishes to leave one valley for another, his worldly belongings are but slung over his back, and he plods his way on to the next cotton district, where he is certain of immediate employment. At times part of a crop is ruined by thieves who at night go out into the country and pick the cotton from the plants, later selling it as their own, sometimes to the same planter from whom it was stolen. *Acequias* are often closed and the water diverted to another section of the valley, at the expense of the unfortunate producer who, being allowed a certain amount during a certain time, does not discover the theft until too late, and then the water is back to the original fields, his time has expired, and his next door neighbor is demanding his supply; so that the water must pass on within a few feet of the unwatered plants, which must suffer in order that others may flourish.
>
> "Modern methods and machinery are a nightmare to the Peruvian uneducated workman, whose only aim is to obtain sufficient money to enable him to continue the same life which has been followed by his class for so many generations past."

The living conditions are far from satisfactory, but employers who seek to improve the conditions get scant cooperation from the ignorant laborers who are accustomed to this plane of living.

Small adobe houses are furnished the laborers. Only the better ones have tile or concrete floors. On many of the larger estates they stand in long rows, frequently around a hollow square. Each family has one large room and a sort of kitchen, or in some cases, two rooms and a kitchen arrangement. As it seldom rains in any of this territory, the roofs are usually of adobe, mixed with stable manure and straw as a binder; a very little rain plays havoc with the interior. The Government now provides that all adobe houses must be made ratproof by being built of concrete to a certain distance above the ground, in order to combat the frequent

[11] Only Egypt has a greater yield per acre (367 pounds), *Foreign Crops and Markets* Vol. 14, No. 10, March 7, 1927, p. 306. Department of Agriculture, Washington.

[12] Klinge, Gerardo, of the Sociedad Agricola "San Nicolas," Lima, Personal communication.

[13] Miller, P.B., "Future Outlook as a Cotton Producing Country," *West Coast Leader* (*Annual Cotton Number*, 1925), pp. 56 ff.

outbreaks of bubonic plague, which has become epidemic in many parts of Peru.

Cost of Production

The cost of production in Peru varies widely according to the particular conditions of each estate; in 1922 the average cost of production of a bale of cotton (assuming a 500-pound bale) varied from \$70 to \$80, these figures including the rental value of the land and all cultivation expenses. In that year a 500-pound bale of cotton was worth anywhere from \$140 to \$160, depending on the grade. Hence profits that year would have been approximately 100 per cent. With the lower prices, these profits naturally decrease very rapidly.

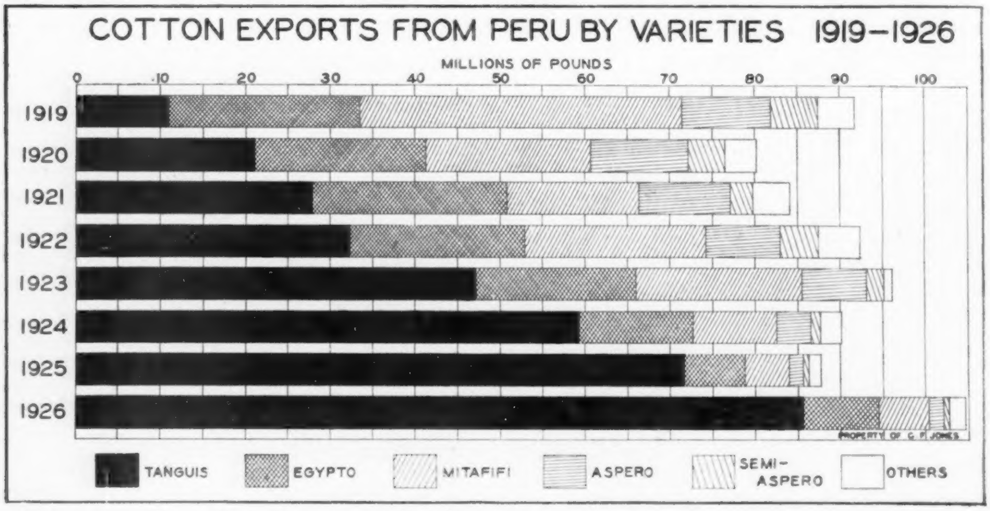

FIGURE 9.—Since 1919 the continued high export movement of cotton from Peru has resulted primarily from the phenomenal rise in the shipments of Tangüis, as all other varieties have registered a striking decline. In 1919, Tangüis was third in rank and made up only 12 per cent of the total exports of cotton, whereas in 1925 it constituted 81.7 per cent of foreign shipments. The future of cotton in the export trade will depend in a large measure on the extension of this wilt resistant variety, on the prevention of Tangüis from reverting to old types, and upon careful grading and standardization of this cotton. (Statistics from Rivera y Pierola, *El Algodon en el Peru, Ministerio de Fomento, Lima*, 1924, p. 12; *The West Coast Leader*, March 9, 1926, p. 7, Lima; *The West Coast Leader*, April 5, 1927, p. 11, Lima.)

DOMESTIC CONSUMPTION

Despite the facts that (1) the making of cotton and woolen textiles is by far the leading branch of manufacturing in Peru, (2) eleven factories turn out about one-half the cotton goods requirements of the country,[14] and (3) five mills produce one-third of the consumption of woolen goods other than the native product of the highland Indians, less than 15 per cent of the cotton production is consumed in the country. While the local mills turn out a variety of products, their strength lies, for the most part, in the cheaper coarse fabrics suited to the great mass of the population. The cotton mills specialize in shirting, gray sheeting, overall cloth, and drills. A

[14] QUANTITIES OF COTTON FIBRE CONSUMED IN THE VARIOUS PERUVIAN COTTON FACTORIES DURING 1923

Name of Factory	*Quantity (Metric Tons)*	*Source of Cotton*
La Union Limitada	254	Lima, Chincha, Canete, Chancay and Lurin
J. M. Forga (La Industrial)	272	Camana, Majes and Ocona
El Huascar	218	Camana, Ica, Abencay and Convencion
La Victoria	342	Rimac, Lurin and Pachacamac
Vitarte Cotton Mill Co.	651	Rimac and others
San Jacinto	378	Rimac
Santa Catalina	30	Canete, Nazca and Chincha
La Bellota	12	Rimac
El Progreso	450	Huacho, Rimac and Pisco
Inca Cotton Mill Ltd.	458	Piura, Chancay, Rimac, Canete, Chincha, Pisca and Ica
Malatesta Hno (Ica)	87	Department of Ica
	3,152	

large amount of the domestic cloth goes into the Andean region to replace the homespun of Indian manufacture. While the country looks to foreign sources for more than half its textile requirements and while they make up 20 per cent of the total imports of the Republic, most of the cotton grown in the coastal valleys is not consumed at home.

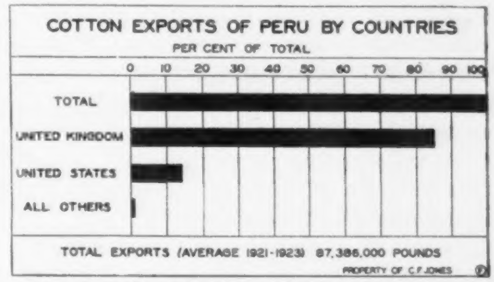

FIGURE 10.—The United Kingdom, the leading cotton importing country in the world, purchases 85 per cent of the cotton shipments of Peru, and supplies that country with its major cotton textile imports.

COTTON EXPORTS

Almost 90 per cent of the Peruvian crop goes into foreign markets (Fig. 9). Great Britain, long the chief buyer of Peruvian cotton, takes about 85 per cent of the total shipments, although increasing quantities have been going to the United States (Fig. 10).

Export taxes on cotton constitute one of the more important sources of revenue for the Peruvian Government. The tax is based on current market prices, in accordance with daily quotations from the Peruvian consuls in Liverpool and New York. The Duties are collected on the unit of the Spanish quintal of 101.4 pounds gross weight, placed on board at port. The taxes are very complicated and vary with the type of cotton, being based on a minimum figure, which is calculated on the line of profitable operations below which no taxes are supposed to be paid.

Tangüis pays 48 cents per quintal (101.4 pounds) when the market is 20 cents per pound at port of embarkation, this rate increasing 10 per cent of the gross value on quotations in excess of that figure. *Mitafifi* and *Smooth* are likewise taxed on this basis. By decree of the 24th of May, 1922, the tax is established on a basis of "Good Fair," instead of on the "Superfine" grade as formerly. Cotton produced in the Piura Valley, mostly *Full-Rough*, although the tax applies to all varieties there produced, pays a tax of 25 cents per quintal when the price is 24 cents per pound, plus 10 per cent additional on all higher quotations. Majes and Camaná valleys pay on a basis of 22 cents per quintal when the price is 20 cents per pound, plus the usual 10 per cent on higher quotations. *Semi-Rough* from Ica valley, east of Pisco, is taxed 25 cents per quintal when the quotation is 22 cents per pound and when the quotation is above this figure, 10 per cent of the gross value is collected. No taxes are levied on cotton produced in the montaña.

Apart from the National tax, a number of regional taxes of varying amounts are levied for one purpose or another. In Piura a tax goes for the improvement of the valley's irrigation system, in Chincha valley for Prado College and sanitation of Chincha Alta, in Chola for road construction, in Cañete valley for sanitation and paving of the towns and for the employment of an expert on cotton standardization, and in Pisco valley for public charity. Thus the movement of cotton from the chief districts of the country is burdened with one or more export taxes and all these hinder the competition of Peruvian cotton with that from other countries, where it flows unchecked by tariffs.

The cotton export business of Peru is largely in the hands of the major importing and exporting firms of Lima, most of which maintain branches or agencies in the important producing sections. A great many of the mercantile firms in the coastal towns also trade in cotton. The bulk of the crop moves through the hands of some fifteen firms—British, German, and North American—

which buy directly from the producer; each usually has its special and long-established clientele. A considerable part of the crop is handled through a system of advances, known in Peru as the *Habilitación* system, the buyers financing their planters and contracting in advance for their crops.

Peruvian cotton is generally sold to be delivered to the sandy beach of the port to await shipment upon the arrival of a boat. As stated before, the product of each valley is shipped through its own particular port and there is no general assembling point [15] (Fig. 11). The Peruvian market is most active in the months from April to September, with the exception of the *Full-Rough* market in the Department of Piura, which is most active from August to March. Considerable Peruvian cotton is sent to Great Britain on consignment, as most British buyers desire to examine the product before accepting it because of the lack of standardized grades.

FIGURE 11.—Mollendo, the most important port of Southern Peru, is one of the leading cotton exporting ports of the country; it serves the Tambo, Ocoña, Majes, and Arequipa districts. Here, as at many Peruvian ports, cargo is transferred from shore by lighters to the ocean vessels, one-half a mile or more off shore. (Photo by C. F. Jones.)

BY-PRODUCTS

While the by-products of the cotton industry are not well developed, cotton seed and its by-products constitute a considerable item in Peruvian export business.[16] Great Britain is the heaviest buyer of Peruvian cotton seed, while Chile comes second, although the latter

[15] COTTON EXPORTS BY PORTS

Port	*Average Metric Tons 1923–24*	*Valley or District*
Puerto Pizarro...	1	Tumbes
Paita..........	4,344	Chira and Piura
Eten..........	94	Lambayeque
Pacasmayo......	443	Pacasmayo and Cajamarca
Chicama........	36	Chicama
Salaverry.......	147	Moche, Virú, and Chao
Chimbote.......	747	Virú and Chao
Buena Vista.....	22	Santa and Chimbote
Samanco........	242	Mepeña
Casma..........	119	Casma
Huarmey.......	182	Huarmey
Supe...........	2,987	Supe Pativilca, and Barranca
Huacho.........	3,986	Huacho and Huaura
Chancay........	4,509	Chancay
Callao.........	2,649	Carabayllo, Yangas, Boca Negra, Piedra Liza-Lurigancho, Huatica, Magdalena, La Legua, Ate Alto y Bajo, Surco, Lurín, and Pachacamac
Mala..........	252	Mala
Cerro Azul......	3,966	Cañete and Lunahuaná
Tambo de Mora..	5,574	Chincha
Chala..........	4	Chala
Lomas..........	1,090	Lomas
Pisco..........	7,198	Pisco, Ica, Palpa, and Nazca
Mollendo.......	7,783	Tambo, Ocoña, Majes, and Arequipa
Ilo............	259	Ilo and Moquegua
Iquitos.........	441	Iquitos region

[16] EXPORTS OF COTTON BY-PRODUCTS, AVERAGE 1923–25

Product	*Metric Tons*	*Value U. S. Gold*
Cotton Seed Oil............	3,422	$1,109,479
Cotton Seed..	15,324	450,855
Cotton Seed Cake..........	15,930	426,225

consumes only about one-twentieth of the amount taken by Great Britain. Great Britain is also by far the largest consumer of Peruvian cotton seed cake, with Germany second, but again with a very small proportion of Great Britain's takings. In cotton seed oil from Peru Great Britain also ranks foremost, with Panama second, and the remainder taken by some ten distinct countries. Naturally, the United States figures very slightly in the purchase of Peruvian cotton by-products.

The cotton seed oil business of Peru is still in its swaddling clothes. In 1925, there were something over 40 factories in the country, the principal centers being Lima, Huacho, Paita, Sullana, Gañete, Pisco, Ica, and Camaná. In Lima there are four refineries and there are several additional ones in the provinces, while occasionally one finds an *hacienda* with its own refining plant. Cotton seed oil and cake are the chief products, followed by soap.

TRENDS

During the five-year period previous to the World War (1909–1910 to 1913–1914) Peru produced an average of 52 million pounds per year and exported 43 million. In the period 1921–1922 to 1925–1926, the crop was 95 million and the export movement 89 million pounds. While both the production and the exports have practically doubled in this period, the export movement is about the level reached in 1919. Despite exceptionally favorable conditions of relief, soil, climate, freedom from disease, and low cost of production, the total crop and the export movement have not increased much during the last eight years because of a lack of expansion in acreage and a lack of capital with which to develop favorably located sections requiring heavy investments for their proper exploitation.

At present nearly all the land to which irrigation water can be applied is producing crops. On the other hand, the completion of new irrigation works now under construction will add materially to the agricultural area of the coastal desert. However, at the present state of knowledge it is estimated that new projects and better methods of using water may not increase the agricultural area by more than 25 per cent. The montaña, although it produces small quantities of cotton, is not considered in this statement for, with its serious lack of labor, capital, sanitation, and transportation facilities, it cannot play a significant rôle in Peruvian cotton trade for a long time, if ever.

With the increase in cotton production all over the world, cotton from the coastal valleys must meet more severe competition. Excellent physical conditions favor the growth of a good quality, long- and medium-length fiber, but as Peruvian cotton is not well graded and the grades are not standardized, they do not enter the most active markets as well as standard grades of cotton from other countries. But the movement is already under way as one leading cotton valley has employed an expert to grade and standardize the output of that valley. When this has been accomplished for all the valleys of the coastal desert, Peruvian cotton can enter world marts and compete successfully with the best of cotton, providing increasing export taxes of one kind or another do not discount all the advantage of standardized grading.

While the production of cotton in the coastal desert of Peru may not increase greatly, an export movement of present proportions will give prosperity to the irrigated valleys, afford a considerable revenue for the government, better the standard of living of the laborers, increase the buying power of the population, and enhance the commercial importance of the country.

BOOK REVIEWS

DEPARTMENT OF COMMERCE

Bureau of Foreign and Domestic Commerce

Commerce Yearbook for 1926.

There is no more significant or comprehensive study published of the year's foreign trade than the Commerce Yearbook. With the growth of exports and imports it has seemed wise to issue two volumes covering the material formerly included in the Commerce Yearbook. The volume about to be issued treats foreign trade of the United States in careful detail. Very shortly a companion volume known as the Foreign Commerce Yearbook will appear covering conditions in foreign countries and international trade. This will be an expansion of the foreign material contained in the latter part of former issues of the Commerce Yearbooks. The 1926 Commerce Yearbook covers intensively such problems as production, employment, and domestic trade; wholesale, retail, and farm prices; foreign trade; agricultural products and foodstuffs; fuel and power; construction; metals; machinery; automotive parts; rubber and rubber products; textiles and clothing; leather and leather products; paper and printing; chemicals and related products; transportation and communication; banking and finance. It contains the latest official statistics of our foreign trade in addition to the text, and many graphs. This volume may be obtained from the Superintendent of Documents, Washington, D. C.

Railways of South America. Part II: Bolivia, Colombia, Ecuador, Guianas, Paraguay, Peru, Uruguay, and Venezuela. By W. Rodney Long. Trade Promotion Series No. 39. Price, 85 cents.

This second volume on the "Railways of South America" represents the latest information available on this subject. Each railway is described in detail, its location, length, rolling stock, and type of construction, being discussed. A brief description of the country through which the railway goes also appears. For each country a carefully prepared railroad map presents the situation.

International Trade in Dried Fruit. By Leslie A. Wheeler. Trade Promotion Series No. 44. Price, 15 cents.

The significance of foreign trade in these products to certain sections of the United States makes this a timely study. It surveys the international trade in various types of dried fruit, presenting statistics and conditions influencing this trade. All these facts make it possible to evaluate the various world markets for dried fruit and to realize the place occupied by American foreign trade in these products.

Rice Trade in the Far East. By J. A. LeClerc. Trade Promotion Series No. 46. Price, 10 cents.

For certain portions of the Far East rice is the important grain food. Its production is concentrated into a few localities. This bulletin discusses not only the movement of rice, but conditions of production, marketing methods, finance conditions, and the background for the demand for rice in the importing countries.

Exclusive Sales Agreements in Foreign Trade. By Bernard A. Kosicki. Trade Promotion Series No. 45. Price, 10 cents.

A careful study of these Sales Agreements so significant in foreign trade was made by the overseas representatives of the Departments of Commerce and State. The results of these studies, together with an introductory chapter on export distribution methods have been assembled in this bulletin.

Ethiopia (Abyssinia) Commercial and Economic Survey. By J. Loder Park. Trade Information Bulletin No. 476. Price, 10 cents.

This is a region about whose trade and general economic conditions very little information is available, consequently this bulletin has somewhat unique value. It presents a general survey of the country and its trade, statistical information, and a map of this little known area.

The following Trade Information Bulletins are of interest. Price, 10 cents.

484 *Origin and Development of the Continental Steel Entente.* J. Joseph W. Palmer.

490 *The Paraguayan Market.* Rollo S. Smith.

488 *Foreign Markets for Agricultural Implements.* Chas. D. Martin.

487 *Electrical Development and Guide to Marketing of Electrical Equipment in Australia.* Lawrence D. Batson.

486 *Cooperage Trade of Great Britain.* A. E. Boadle.

485 *The Motorization of Germany.* H. C. Schuette.

479 *Advertising Automotive Products in Africa.* J. A. G. Pennington.

482 *Foreign Markets for Automobile Servicing Appliances.* G. E. Haynes.

483 *Competition in the International Leather Trade.* J. Schnitzer.

474 *Foreign Markets for Miscellaneous Leather Goods.* Shoe and Leather Mfg. Div.

472 *Business Practice in Greece.* Edwin A. Plitt.

Monthly Summary of Foreign Commerce of the United States. Parts I and II. Price, $1.25 per year.

These Monthly Publications contain the earliest official announcement of current foreign trade statistics for the United States. These statistics are presented by countries, by commodities, and by trade regions. Figures also are given in detail for the trade with the noncontiguous parts of the United States, such as Alaska, Porto Rico, Hawaii, and the Philippines.

Progress in Elimination of Waste. By Herbert Hoover.

An extract from the Fourteenth Annual Report of the Secretary of Commerce covering this most important question.

U. S. COAST AND GEODETIC SURVEY

Inside Route Pilot, New York to Key West. Sixth Edition, 1927. By E. Lester Jones, Director. Price, 30 cents.

This volume contains a detailed descriptive text of the route and excellent maps.

Progress of Seismological Investigations in the United States. By N. H. Heck. Special Publication No. 132. Price, 5 cents.

This embodies the report to the Section of Seismology of the International Geodetic and Geophysical Union, International Research Council. Supplements to the following Coast Pilots have been issued: Alaska, West Indies, Atlantic Coast—Cape Henry to Key West.

The Coast and Geodetic Survey Bulletin, issued monthly, contains much information of interest to the geographer.

BUREAU OF CENSUS

Census of Manufactures, 1925.

For the first time a Census of Manufactures has been taken at the five-year period instead of decennially, as heretofore. The first bulletins of this census are now available for 5 cents each, covering the following industries: Beverages, Flavoring Extracts and Flavoring Syrups Malt; Buttons; Cement and Concrete Products; Furniture; Glass and Mirrors; Lime and Marble, Slate, and Stone Work; Manufactured Ice; The Rubber Industries; Turpentine and Rosin.

Census of Agriculture, 1925.

Further state bulletins giving statistics of the 1925 agricultural census have been issued:

Georgia	10¢
Connecticut	5¢
Delaware	5¢
Maine	5¢
Maryland	5¢
Massachusetts	5¢
New Hampshire	5¢
New Jersey	5¢
Rhode Island	5¢
Vermont	5¢

Animal and Vegetable Fats and Oils. Production, Consumption, Imports, Exports and Stocks, by Quarters. Calendar Years 1925 and 1926. Price, 5 cents.

Survey of Current Business. Subscription price, $1.50 per year.

A significant index of weekly and monthly business conditions in various industries and throughout the country as a whole.

RADIO DIVISION

Radio Service Bulletin No. 121, 5 cents.
Radio Service Bulletin No. 122, 5 cents.

BUREAU OF MINES

II:28 *Sulphur and Pyrites in 1925.* Helena M. Meyer. 5 cents.

I:20 *Gold, Silver, Copper, Lead, and Zinc in Utah in 1925.* V. C. Heikes. 5 cents.

I:22 *Gold, Silver, Copper, Lead, and Zinc in Idaho and Washington in 1925.* C. N. Gerry. 10 cents.

II:31 *Coke and By-Products in 1924.* F. G. Tryon and others. 25 cents.

280 *Petroleum Refinery Statistics, 1916–25.* G. R. Hopkins. 30 cents.

267 *Acid Processes for the Extraction of Alumina.* G. S. Tilley, R. W. Millar, and O. C. Ralston. 15 cents.

244 *Fluorspar, Its Mining, Milling, and Utilization, with a Chapter on Cryolite.* Raymond B. Ladoo. 35 cents.

I:18 *Zinc in 1925.* Amy Stoll. 5 cents.

II:27 *Petroleum in 1925.* G. R. Hopkins and A. B. Coons. 10 cents.

I:19 *Copper in 1925 (General Report).* C. E. Julihn and Helena M. Meyer. 10 cents.

269 *Quarry Problems in the Lime Industry.* Oliver Bowles and W. M. Myers. 25 cents.

BUREAU OF NAVIGATION

113 *American Documented Seagoing Merchant Vessels of 500 Gross Tons and Over.* 10 cents per copy, 75 cents annual subscription.

114 *American Documented Seagoing Merchant Vessels of 500 Gross Tons and Over.* 10 cents per copy, 75 cents annual subscription.

BUREAU OF STANDARDS

325 *Ceramic Properties of Some White-Burning Clays of the Eastern United States.* 20 cents.

121 *Technical News Bulletin.* 25 cents annual subscription.

122 *Technical News Bulletin.* 25 cents annual subscription.

96 *Organizations Coöperating with the National Bureau of Standards.*

BUREAU OF FISHERIES

1016 *Refrigeration of Fish.* Harden F. Taylor. 30 cents.

144 *Fisheries Service Bulletin.*

145 *Fisheries Service Bulletin.*
Bulletin of the U. S. Bureau of Fisheries.

1015 *The Smelts.* Wm. Converse Kendall. 60 cents.

NOTE.—Where prices are indicated in the above bulletins they may be obtained from the Superintendent of Documents, Washington, D. C.

It may be of interest to geographers to know that airplane views of Southeastern Alaska made last summer by the Navy Department at the request of the Geological Survey of the Interior Department and Forest Service of the Department of Agriculture will soon be available for purchase. Those interested in these pictures may obtain from the Forest Service, Washington, D. C., an index map showing the location of the area covered by each photograph. The price for each group of three pictures is $1.00 for unmounted and $1.40 for mounted.

Helen M. Strong.

BROOKS, C. E. P. *Climate Through the Ages.* 439 pp., 39 figs., bibliog., index. R. V. Coleman, 522 Fifth Ave., New York, 1926: $5.00.

This volume, admirably entitled "Climate Through the Ages," gives us not only a critical review of the climatic history of the earth, but also a quantitative evaluation of the various causes of climatic change. With marked success, the author shows the adequacy of fluctuations in the important factors in climate to account for the outstanding features in the changing climates of the geological and historical past. These are, particularly, the distribution and height of land, with their attendant temperatures, pressure systems, winds, ocean currents, and precipitation. Changes in atmospheric transparency, i.e., in volcanic dust and cloudiness, are also recognized as potent factors.

The climates of geological time are simply divided into the long-enduring mild, or nonglacial, type and the short-lived glacial, or iceage, type. This division without important graduations between the mild and the cold, is possible, the author claims, because but a slight amount of primary cooling sufficient to begin the formation of ice in the polar regions after a mild period will, through the secondary cooling by the ice and snow, make high latitudes become very much colder. Thus an initial fall of a degree or two may eventually become a drop of 45° F. The clever development of this idea is the outstanding contribution of the book.

Another valuable phase of the work is the author's climatic delineations of geological periods, based on geologists' maps of the varied geography of those times. The author works mainly with principles of continentality and temperature deduced from present geography. His results suggest that the bold continental-drift and polar-wandering theory of Wegener and Köppen is unnecessary to explain even such anomalies as regional glaciation on the equator, in Upper Carboniferous time. The author caps his admirable discussion of geological changes of climate with a long-range forecast of the general trend toward warmer, quieter, and drier climates the world over during the next million years.

A quarter of the book is given over to a full discussion of all types of evidence of changes of climate in historical times, leading to a fair presumption that these changes have been practically simultaneous over the entire earth. These fluctuations appear to be zonal in character, with a tendency to opposition between low and high latitudes.

The reader is spared the tedious details of numerous computations, the laboriousness of which can be appreciated only by the author himself. But this does not mean all is clear sailing, for some of the arguments are too abbreviated and are hampered by typographical errors in text and diagrams. The reader, at times, gets the impression that the author is pyramiding on insecure or even partly inapplicable assumptions, and reasonable proof is not always evident. Well-rounded, fair in criticism, stimulating, this contribution takes its place as the best book on the intricacies of changes of climate.

CHARLES F. BROOKS.

NELSON, HELGE. *Nordamerika: Natur, Bygd och Svenskbygd.* 523 pp. in 2 volumes; figures, plates and maps. Magn. Bergvall, Stockholm, 1926. 7.50 Swedish crowns (about $2.00).

Professor Helge Nelson, director of the Geographic Institute of Lund University, the scientific center of South Sweden, has recently published, as part of the results of his researches in America, a noteworthy work, *North America: Its Nature, Communities, and Swedish Districts.*

From time to time in the long series of years that Nelson has been engaged in his investigations he has published detached articles and accounts of which his book on Canada (Stockholm, 1922) may be considered representative. Though these publications, like the book under review, are printed solely in Swedish, yet he is well known among the English-speaking peoples (for the work in his special field) through his article in English "The Interior Colonization of Canada in the Present Day, and Its Natural Conditions" (Geografiska Annaler, Stockholm, 1923). By his scholarly investigations in this field he has become well recognized as a competent geographer of rare

geographic vision, with complete grasp of the subjects he handles.

For Sweden and the Swedes of the homeland, as well as the descendants of Swedish immigrants to America, the work is of particular value in that the author has held as his objective the interpretation of the Swedish-American people in relation to the environment to which they have transferred themselves and in which they are now taking so active and significant a part. Nothing can be more true than the author's declaration in the preface: "No foreign land can be so rich in sentimental interest, so fraught with practical significance, for us Swedes, as North America, meaning the United States and Canada. Thence have nearly all of our emigrants directed their way; there have they broken ground and built their homes; with them thousands upon thousands of homekeeping Swedes are connected by ties of blood and frequent messages. But even if America did not hold within her boundaries the largest Swedish population beyond our home borders, we should still be deeply interested in her activities for the vast rôle she plays in the world's economy, for the major share she engages in Sweden's foreign trade. The United States, the old pioneer land, is the world's greatest land of industry and agriculture, in many fields the triumphant competitor with Europe. Canada's broad domain constitutes one of the world's undeveloped granaries, a somewhat chilly lure for the surplus labor of Europe, who have the will and desire to engage in a strenuous struggle for land and independence, with ox and plow."

The first volume of the book gives a general geographic survey of North America. In broad and convincing lines the author sketches in the large significant features of the continent—its outlines and morphologic provinces; its climate; its plant life and animal life; its peoples; its agriculture; its forests and forest industries; its power resources, mineral reserves; its industrial regions; its waters and their fish; its routes of communication, travel and trade; its political divisions; and finally the distribution of its cities and their types.

The second volume is more arresting in its appeal. It consists of twenty-three separate items written with a certain independence and individuality, describing as many geographic landscapes or environments. Among these are the following: "White and Black in Cotton Land"; "Washington, the Little Capitol of a Mighty Nation"; "New York, the World's Metropolis"; "New England, Where the Forest Returns and the Fields Lie Fallow"; "Worcester, the Center of the New England Swedes"; "New Sweden, a bit of Sweden in Maine"; "The Annapolis Valley of Nova Scotia"; "Niagara and Its Geologic History"; "Chicago, the Metropolis of the Interior Prairies"; "Swedish Centers in the Central Plains and Their Borderlands"; "French Canada's Old Cities"; "French Canada's Settlements"; "Canada's Prairies and Their Development"; "The Northern Woods and Hunting Grounds together with the Hudson Bay Company, Their Master"; "The Tundras of the Arctic Archipelago"; "The First Pacific Railway"; "C. P. R., the Canadian Pacific Railway"; "Utah's Irrigated Oasis"; "The San Joaquin Valley of California and Its Swedish Towns"; "The Yellowstone Region"; "The Cordilleran Profile from Calgary to Vancouver Island"; "The Fjord Coast of the Pacific"; "The Character and Natural Resources of Alaska and the Yukon Territory"; "Swedish America and We."

The whole work shows a strong personal touch, attained by widespread travel in Canada and the United States as well as personal researches and studies. This is particularly conspicuous in the illustrations which in large part consist of the author's own pictures and maps made either by himself or by his assistants in Lund University. All this would certainly appeal strongly to the American public, to its profit and interest, were it not denied reading the book by its being printed in the Swedish language. The strongly personal flavor with which the author has written does not detract in any way from its interest or value; in fact the author's individual treatment enhances the value of the book and places it in the forefront of the many which treat of the geography of North America. The book reveals a wide acquaintance with the land both by personal contact and by the author's wide reading. The bibliography is long and comprehensive, yet withal selective indicating how thoroughly the author has studied his field.

All in all, Nelson's new work is a text-book on North America that compares favorably with the ten best on the geography of North America. It is better than most of the similar publications in England, Germany, France, or other countries, dealing with North America; and finally it is for us Swedes of Sweden, all told about six million people, a joy and satisfaction that we have in our own language and by one of our own authors, so satisfactory, so engaging a work, on that part of the world with which we have so much in common. How well Nelson's book on North America has been received in Sweden is shown clearly by the fact that it was lately awarded the gold medal of the Swedish Academy of Science, an honor that it shares with only one other geographic work, Gunnar Anderson's *Monographic Treatise on Australia.*

Olof Jonasson.

Day, Cleve. *The Distribution of Industrial Occupations in England, 1841–1861.* viii, pp. 156. Yale University Press. Transactions of the Connecticut Academy of Arts and Science, Vol. 28, March, 1927, pp. 235.

The above work is a rather exhaustive statistical survey of the distribution of industrial occupa-

tions in England in 1841 and 1861, based on the National Census. The dates are significant since the first complete census of occupations was made in 1841, and because at that date local occupations were still numerous, as they had only in a measure been eliminated by the development of the factory system, and the improvement of transportation. The vast amount of data involved in the investigation (400 industrial occupations in over 40 counties or statistical districts) made it necessary for the author to "present semi-finished material rather than refined conclusions," and sampling was resorted to in case of the 1861 census. The author's purpose, as he himself states, was to "describe rather than explain the distribution of industrial occupations." For a review of the literature on the factors affecting concentration, a matter which "already has been the subject of elaborate investigation," the reader is referred to Alfred Weber, ***Industrielle Standortslehre in Grundreiss der Soziolokonomik***, 6:54–82.

The industrial occupations were divided into types according to the size of the market served, the latter being deduced from the distribution of workers. If workers in a given trade were uniformly distributed throughout the various counties according to population, they undoubtedly supplied local markets and hence the occupation was classified as local; conversely concentration of workers was taken to indicate a national market.

The "Index of Concentration," secured by subtracting from 100, the per cent of the total population in concentration areas comprising half of the workers in a given trade, was found to be the most satisfactory way of indicating the distribution of trades showing marked concentration. The standard coefficient of deviation, though not in all cases satisfactory, was used as a measure of dispersion. The two measures of distribution may be combated, however, since a "relatively high index of concentration, 80 and above, indicates a standard coefficient of deviation, approaching or exceeding one."

As a result of statistical analysis the author found that four more or less natural groups of industries could be recognized, viz., Metropolitan, National, Provincial and Local.

The Metropolitan group, consisting of local workmen supplying the London trade, was relatively unimportant, comprising only about one-half of one per cent of the workers investigated. In 1841, London contained about one-eighth of the fifteen million people living in England, and "contained an immense number of people in industrial occupations, yet most of these worked for Londoners, providing things which appealed to the tastes of luxurious customers, and rarely upon machine processes of production; being often associated with a depressed class of labor." London was above all a great center of consumption, such positive contribution as it made to the economic life of the country was commercial rather than industrial.

Industries having an "index of concentration" of over 75 per cent were classed as "National." That concentration of industry had made much progress by 1841 is indicated by the fact that 47 per cent of the workers considered in the investigation fell in this classification. Textiles, metals and pottery were the principal industries in this group. Textiles alone employed four-fifths of the workers in industries of the "National" type, while the textiles and metal trades combined comprised over seven-eighths. England's greatest, "National" industry, cotton, was already concentrated where it is now localized. Lancashire and Cheshire Counties, with less than one-fifth of the English people, had over four-fifths of the cotton workers.

Occupations given "Local" classification had general distribution, and are assumed to have supplied markets a few miles in radius. This group comprised 41 per cent of the workers studied. Provincial occupations were those not falling in the other groups. They comprised 11 per cent of the total workers. The suggestion is made by the author that some of the trades falling in Provincial classification were in process of transition from local to national distribution.

Tables in the Appendix contain a complete classified list of occupations, giving the number of workers employed, and the degree of concentration; the latter is expressed both by the index and the coefficient of deviation. The tables, also, give the county or counties in which the trade was most concentrated.

The reviewer believes this to be a significant study for economic geographers, because of the light it throws upon the distributions of occupations in England at any significant period. Its greatest significance, however, lies in the fact that the author has solved many of the difficulties involved in using statistical methods in investigating the facts of geographical distribution.

Students contemplating similar statistical investigations will find Chapter VII particularly helpful.

C. J. BOLLINGER.

ANDREE, KARL. *Geographie des Welthandels. Die Aussereuropäischen Länder.* Volume II, xvi and 1,110 pp. L. W. Seidel & Sohn, Wien, 1927. 10 x 7 inches. Price unbound F. 9.00; bound in cloth F. 10.00; bound in leather F. 11.50.

The second volume revised of this magnificent work promises to be of even more importance to the geographers of the world than Volume I has been. Exhaustively it takes up and treats every phase of the subject to which it is devoted in every land and isle that has not been considered in Volume I. Thoroughly it discusses these

lands beyond the border of Europe in their relation not only to Europe but to one another. Logically it presents the complex interactions and interdependencies of the several physical backgrounds and the various peoples affected by them over the whole surface of the earth. Exhaustively, thoroughly, and logically—these terms characterize the volume.

The "Orient," written up by Richard Uhden in incomparable fashion in the first 110 pages of the book, is a valuable contribution to the geographic literature of the lands of Western Asia and Northern Africa including the Sahara. "Africa South of the Sahara" is treated by Dr. Franz Thorbecke in the next 115 pages of the volume, a thorough discussion that adds much that is new to the knowledge of the Dark Continent. Dr. Hans J. Wehrli, with complete grasp of his subject, discusses "Nearer and Farther India," Dr. Wilhelm Volz writes of "Southeast Asia," and General Karl Haushofer makes "China and Japan" his contribution to the volume.

"North America" is adequately and satisfactorily described by Dr. Kurt Hassert in his appraisal of the new trade colossus among the continents. With keen discernment he has selected the significant major features of its geography and given them their proper emphasis. This section is particularly well done. Dr. Karl Sapper gives the "Caribbean Lands" equally satisfactory treatment, and Dr. Otto Maull does full justice to "South America." "Australia and Oceanica" are fully treated by Dr. George Dressler, while the "Polar Regions" by Dr. Felix Lampe concludes the volume. Each region treated has received all the attention it deserves in world trade, a remarkable balance being maintained throughout the volume for each separate land.

These masters of geography have excelled themselves in this revision of Andree—Heiderich-Sieger's splendid original work. They leave little to be said further in the way of salient facts, geographic interpretation or clear forceful presentation. Their labors have placed all geographers under obligations to them. They deserve all the credit that will certainly accrue to them.

And L. W. Seidel and Son, of the celebrated publishers of Vienna, likewise deserve unlimited praise for the superior way in which they have issued this work. It is well bound, the paper and type are well chosen, and in every way the mechanical work has been well done.

The conclusion follows: "Geographie des Welthandels," its two volumes, is indispensable to geographers; it is invaluable to the business man and the statesman; it is a rich mine of fact and figures to every student; it is a reference book that every library should have on its shelves; and it is a desirable addition to the geographical literature of the world.

W. ELMER EKBLAW.

American Petroleum—Supply and Demand. A report of the Board of Directors of the American Petroleum Institute by a Committee of Eleven Members of the Board. xiii, 269 pp. New York: McGraw-Hill Book Company, 1925.

In their *American Petroleum—Supply and Demand*, the Committee of Eleven Members of the Board of Directors of the American Petroleum Institute (a personnel of leaders in the world of petroleum) has contributed notably to our literature on this important resource.

The committee divided the work into three major classifications: (1) "The Growth and Development of the American Petroleum Industry," (2) "The Future Supply," and (3) "The Future Demand." It based its opinions of our *future supply* on the best information obtainable from the outstanding men in the industry—executives of life-long experience in the production, refining, marketing, and distribution of oil, as well as geologists, chemists, and engineers. It derived its information on the future demand from authorities both within and without the industry. From the latter group, it secured information on such vital topics as our future population, its industrial growth, the probable increase, in consequence of such growth, in the number of automobiles and oil-consuming engines, and on mechanical changes which will conserve oil through more efficient utilization. In all the committee secured the services of more than 250 persons, and consumed nearly six months in assembling the data and drafting the report.

In brief, the book presents both a comprehensive and detailed discussion of the future supply and demand of petroleum. It is divided into three parts. Part I consists of a Letter of Transmittal and a Summary of both the Supply and Demand Reports (the reviewer considers the latter of great value); Part II of the Supply Report comprising sections of (1) Petroleum Wells and (2) Oil Shale, Coal, and Lignite; and Part III of the Future Demand Report. Illustrative material pertinent to the oil industry and lists of highly valuable tables accompany Part III.

Probably the reviewer can give no better idea of the contents of the book than by listing just a few of the thirteen conclusions which are drawn from the completed work:

1. There is no imminent danger of the exhaustion of the petroleum reserves of the United States.
2. Waste in the production, transportation, refining, and distribution of petroleum is negligible.
3. It is estimated that after pumping and flowing there will remain in the area, now producing and proved, twenty-six billion (26,000,000,000) barrels of crude oil, a considerable portion of which can be recovered by improved and known processes

such as flooding with water, the introduction of air and gas pressure and mining, when price justifies.

4. Improved methods of deep drilling below oil sands now producing will disclose in many areas deposits not hitherto available, which will be tantamount to the discovery of new fields. Improved methods of producing have been perfected which will make possible recovery of oil from these lower levels. The limit of deep drilling has not yet been reached.
5. The major oil reserves of the United States lie in some one billion one hundred million (1,100,000,000) acres of lands underlain by sedimentary rocks, and not fully explored, in which geology indicates oil is possible. With extended search new supplies will be found therein.
6. The nation has an additional reserve in the vast deposits of oil shale, coal, and lignites from all of which liquid fuel and lubricants may be extracted if and when the cost of recovery is justified by the price of these products. These deposits are so huge that they promise, under conservative estimates, an almost unlimited supply.

Some of the above conclusions are at such variance with those to be found in other recent works on petroleum that the reader may become skeptical regarding their trustworthiness. For instance, he may be surprised to note that our reserves are *not* in "imminent danger." He probably has believed that our future as regards petroleum is not bright. And such an attitude has been justified in lieu of the pessimistic estimates of our petroleum reserves by such eminent men as C. R. Van Hise, D. T. Day, Ralph Arnold, and David White. But the committee points out that all these estimates, while deserving of respectful consideration, were grossly inaccurate in certain respects. The reader may also believe that waste has triumphed wherever man has come into contact with petroleum. If so, he will challenge the committee's conclusion that "waste in the production, transportation, refining and distribution of petroleum is negligible." And he may react similarly towards some of the other conclusions.

While it may seem that several of the committee's deductions are questionable, the reviewer feels that they are reliable—at least as reliable as human beings can make them. The committee, in undertaking this work, faced an almost superhuman task.

Only a peep has been given into *American Petroleum*, but that suffices to prove that here is a book with intrinsic value. Every economic geographer should own it, for it is indispensable as a reference.

For contributing so excellent a book, the American Petroleum Institute merits the gratitude of the entire nation, for what natural resource plays a more potent and significant rôle in American industrial and commercial life?

LANGDON WHITE.

LIEFMANN, ROBERT, and ANGELBERGER, FRANZ. *Mineralölwirtschaft.* 128 pages; maps, diagrams, charts, and pictures. Ferdinand Hirt, Breslau, 1927. 3.50 Rm.

A valuable contribution to any man's technical library, this unassuming but comprehensive little volume deserves special recommendation to the geographer, not only for its rich factual content but for its compact presentation of such a broad subject. It does not overstep the bounds of geography to intrude upon geology on the one side or upon economics on the other. The authors have shown a wise restraint in their field.

Especially interesting are the discussions in the fourth chapter of the book, of the "Evolution of the Standard Oil" group, and in the fifth chapter of the "World Politics of Petroleum." As innocent bystanders the authors view the great English-American struggle for petroleum supremacy in the world's affairs, and their observations, naïve and pertinent indeed, are illuminating to the participants.

Mineralölwirtschaft is as good a reference work on this subject as has appeared.

W. ELMER EKBLAW.

OUR CONTEMPORARIES

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Vol. XVII, No. 3. July, 1927

The Templed Promontories of the Ancient Mediterranean. 34 pages. Ellen Churchill Semple.

With exceeding thoroughness, characteristic of all her work, Miss Semple has assembled, sorted, and presented in this article an exhaustive mass of material valuable to both geographer and historian. It is as interesting as it is valuable.

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An excellent summary of many fascinating hypotheses, but too brief adequately to state the merits of the several theories.

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Textually interesting, pictorially fascinating, this article tends to lure every one who reads to a life of exploration.

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A report of progress.

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Joy rampant in the heart of a lover of the hill-tops.

Suburban Industrial Development of Philadelphia: Delaware County. 11 pages. Frank E. Williams.
A thorough, substantial contribution to geography.

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A splendid contribution to the agricultural phase of economic geography.

Municipal Ownership in the Electric Light and Power Industry of Massachusetts. 10 pages. Herbert B. Dorau.

The Size of Landholdings in Wisconsin. 15 pages. Jonas Sturlaugson.
Worth study by the geographer.

ANNOUNCEMENT

THE series of articles on *South American Commerce*, by Dr. Clarence F. Jones, of which the seventh instalment, "The United States and its Chief Competitors in South American Trade," appears in this number, is concluded in this issue.

The series of articles, ***Agricultural Regions of the World***, is continued in this issue with the fourth instalment of ***Agricultural Regions of North America***, by Dr. O. E. Baker of the United States Bureau of Agricultural Economics. It is richly illustrated by many excellent maps in black and white, presenting the latest agricultural data available. This superb article will be completed in later issues, when another up-to-date colored map and the final textual material will conclude one of the best popular, thoroughly scientific presentations of North American agricultural geography in print. The next instalment in October will include important new data which have recently been tabulated and made available.

Agricultural Regions of South America, by Clarence F. Jones; ***of Africa***, by Homer L. Shantz; ***of Australia***, by Griffith Taylor; and ***of Asia***, by Olof Jonasson, will follow in later issues.

All these articles will be illustrated by maps, charts, and pictures. The series will constitute one of the most complete geographic discussions of the world's agriculture thus far published.

To obtain the complete series of these extremely valuable articles, which present for the first time on such a comprehensive and accurate basis the significant divisions of the world's most important industry, it will be necessary to subscribe at once for ECONOMIC GEOGRAPHY, and date back to the October, 1926, issue.

In addition to this series of articles on agriculture, other series are being initiated; every issue will also contain four or five other articles dealing with urban and regional geography, with problems of land utilization, with programs of development of resources, with commerce, with transportation, with health, and with the hundred and one other subjects that are of present geographic interest, all by the most competent and best informed authorites in their respective fields. ECONOMIC GEOGRAPHY is indispensable to the intelligent citizen.

The subscription price to all new subscribers in the United States and possessions is $5.00 the year or $9.50 for two years. To all foreign countries, $5.50 the year or $10.00 for two years.

THE STAFF

"Nature has been so silent in her persistent influence over man, that the geographic factor in the equation of human development has been overlooked."

ELLEN CHURCHILL SEMPLE.

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